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CITRUS INDUSTRY OF FLORIDA

PART I

Citrus Growing in Florida

By

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PART II

Packing House Operation

By

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PART III

Citrus Marketing

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Citrus Processing

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PART V

Agencies Serving the Citrus Industry

DEPARTMENT OF AGRICULTURE — TALLAHASSEE, FLORIDA
NATHAN MAYO, *Commissioner*

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PART I

CITRUS GROWING IN FLORIDA

By

A. F. CAMP

Vice-Director in Charge, Citrus Experiment Station

I.

History

STRANGELY ENOUGH, citrus, which is today one of the major fruit crops of the western hemisphere, is a native of the Orient and was unknown in the new World until after its discovery by Columbus. Stories about citrus fruit occur in the oldest Asiatic literature, where it was evidently one of the major fruits, its development seemingly centering in southeastern Asia. It was carried by slow stages across Persia to Europe. First to reach the Mediterranean area was the citron, which is mentioned in the very early European and Arabic literature; it was followed by the sour or Seville orange and the lemon, but the dates of their introduction can not be fixed accurately for any particular European area and the sour or bitter orange seems to have spread through the Mediterranean area during the period from 500 A. D. to about 1100 A. D. with both the Arabs and the Crusaders helping to spread its culture. Because travel was slow, its distribution was slow, but by 1300 A. D. it seems, with the lemon, to have been well scattered through Europe. Dates can only be approximate because the introduction into Europe was not a clear-cut thing, but a gradual spread by travelers and traders from India and Indo-China through Persia and Palestine, and thence across North Africa and Southern Europe. At any rate, by the time Columbus discovered the countries of the western hemisphere, citron, sour oranges and lemons were widely scattered throughout the Mediterranean countries and grown extensively in Spain, Italy and along the North African coast.

Sweet oranges, to which group belong the modern varieties of commercial oranges, probably did not reach

Europe until about 1400 A. D. At the time of Columbus' adventure, the sweet orange was probably still a novelty and its growing limited to royal courts and the grounds of wealthy people. From all accounts we may judge that Columbus brought with him to the New World the sour orange, the citron, and the lemon; and the sweet oranges were introduced later by other explorers and colonists. Wherever Spanish settlements were made, citrus plantings soon appeared, and in Florida the Indians carried oranges with them and dropped their seed in the hammocks and heavily forested areas so that many years later the thick forests were found populated with wild sour orange trees and many travelers supposed them to be native to Florida. In some cases, these were topworked to sweet oranges and constituted some of the very early groves. Somewhat later sweet oranges appeared, and some of these even became denizens of the wild country in Florida, and the discovery of these wild trees by early travelers gave rise to the common opinion that sweet oranges also were natives of Florida. There is no reason, however, to believe that oranges, grapefruit, limes or lemons were ever found in this country before the Spaniards and other travelers from Europe introduced them.

Early settlers in Florida developed orange groves, and particularly around the Spanish settlement of St. Augustine, by 1579, there were citrus plantings. By 1800 there were numerous groves planted by the Spaniards and other settlers, principally along the coast at such points as St. Augustine and around Tampa Bay as well as along the St. Johns River. After the annexation of Florida by the United States in 1821, settlers from the North steadily expanded the groves. This expansion received a sharp setback in 1835 when a severe freeze killed many of the trees to the ground. Later plantings were scattered along the waterways of Florida and along the coast where access could be had to water transportation to New York and other eastern ports. In those days there were no railroads in Florida and little in the way of other roads so that the rivers and the lakes connected with them, served as the main channels of commerce, and groves had to be planted sufficiently close to these waterways to make it possible to market the fruit. Naturally, the development was most extensive around the seacoast and in the northern part of the state along the St. Johns River south of Jacksonville and extending up the Oklawaha River to the area in southern Marion County, where a development was started in the vicinity of Citra.

After the Civil War development was rapid. As the cattle business expanded in the flatwoods areas, seedling orange trees were planted in the fenced enclosures where cattle were brought for branding and marketing. Many a fine old seedling grove was "cow-penned" in the early period of its development.

From the early plantings, fruit moved by sailing schooner up the eastern seaboard for marketing as a luxury fruit during the holiday season when few fruits were available in the snowbound North. The fruit was packed in barrels padded with Spanish moss, and transportation was hazardous.

In 1886, the Florida crop reached for the first time a volume of 1,000,000 boxes. Railroads were coming into the state and improvements in communications made possible the development of citrus groves away from the waterways. Expansion was steady from 1886 to the freezes in the winter of 1894-'95, by which time the production had reached about 5,000,000 boxes. It is interesting to note that California was still far behind Florida at that time, producing only about 2,500,000 boxes (see Table II). The freezes of 1894 and 1895 wrecked the citrus industry in Florida, and the crop in the succeeding year was only 150,000 boxes compared with over 5,000,000 boxes the year before. Recovery of groves in most cases was started immediately after the freeze, but was interrupted by another extremely severe freeze in 1899. The acreage in the northeastern area of Florida never again attained the extent that it had prior to these three freezes nor anything like the total production.

These early plantings had been made on locations selected primarily because of the character of the soil.

The incoming growers knew very little about problems of natural cold protection and their selections of grove sites were not based on the fact that areas close to bodies of water were warm, but primarily because the bodies of water meant ways of transportation. The freeze of 1894 and 1895 brought squarely into the foreground the problem of cold protection and resulted in a spread of the citrus industry to the south. This southward trend was speeded by the freeze of 1899, and the greatest area of the citrus industry today is in central Florida, where the cold hazards are far less than those which faced the early growers.

This meant in a large measure that the development of increased production in the succeeding years was based on new groves rather than rehabilitating old ones, and it was not until the season of 1909-'10 that the Florida crop again exceeded 5,000,000 boxes and it was not until 1919-'20 that it surpassed 10,000,000 boxes (see Table III). By this time it had been found that trees could be produced on the high, warm, sandy ridges by using rough lemon stock, and it is these high, warm locations that represent the bulk of the acreage of citrus at the present time. Prior to the discovery of rough lemon stock, sour orange and sweet orange stocks had been mainly used and neither of these was entirely satisfactory on the light sandy soils with their low fertility and irregular moisture supply, so that in a sense the industry's size today is based mainly on the discovery of rough lemon stock because it made possible the use of lands not formerly suited to citrus production.

For many years oranges were the main citrus crop in Florida. A few grapefruit were shipped between 1880 and 1885, but prior to that time they had not been considered useful for human consumption, though grown in dooryards in Florida. Just where they originated is more or less of a mystery because grapefruit as such has never been found as a native in the Asiatic countries. The Shaddocks, or pummelos, which are similar to them in appearance, were brought to Jamaica by Captain Shaddock in the early days and widely grown there at that time, and it is possible that the grapefruit occurred as a sport or variant from the Shaddock and was carried from Jamaica to other islands and eventually to Florida. Until the great freezes of 1894 and 1895 they had never entered into the market to any great degree but after these freezes and as the new areas were opened for citrus, the production of grapefruit gradually increased and in recent years has become a big factor in citrus production in Florida.

The production of citrus fruit has become the largest single factor in the fruit business of the United States today, and now approximately equals the production of all other major fruits, including apples, peaches, pears and grapes. In Table I will be found tree counts for the various categories of citrus in Florida to give the reader an idea as to the extent of the industry, and in Figure I will be found a map showing roughly the areas of concentrated citrus plantings. It should be noted that this distribution map shows concentrations of citrus in certain areas in which the soil and temperature conditions are most favorable. In Tables II and III will be found a record of production of oranges, grapefruit and tangerines for Florida, and attention is called to the effect of the freezes of 1894 and 1895 (Table II), of 1917 and 1927 (Table III), and the negligible effect of the freeze of January, 1940 (Table III), which emphasizes the progress that has been made in eliminating cold areas and improving tree conditions by proper fertilization and spraying. In Table V the production of citrus in the United States is compared with the combined production of apples, peaches and pears grown in the United States.

When it is considered that the production of citrus in the United States is consumed largely outside of the bounds of the areas in which it is grown and consequently almost all of the fruit must be transported in some way from the grower to the consumer, the production is amazing. Apples and other fruits may move extensively to local markets with only a portion transported to distant markets, while almost all of the citrus crop must be graded and packed in a way that will permit its movement for hundreds of miles to the con-

CITRUS PLANTINGS IN FLORIDA

TABLE I—NUMBER OF CITRUS TREES BY COUNTIES AND VARIETIES AS OF 1952 ACCORDING TO RECORDS OF FLORIDA CROP AND LIVESTOCK REPORTING SERVICE

Counties	Bearing Orange Trees		Bearing Grapefruit Trees		Bearing Tangerine Trees	
	Number (000)	Percent of Total	Number (000)	Percent of Total	Number (000)	Percent of Total
Brevard	797	3.8	240	3.5	32	2.2
DeSoto	457	2.2	90	1.3	32	2.2
Hardee	692	3.3	55	.8	42	2.8
Highlands	823	3.9	354	5.2	51	3.4
Hillsborough	1,164	5.6	229	3.4	64	4.3
Indian River	496	2.4	610	9.0	22	1.5
Lake	2,444	11.7	645	9.5	154	10.4
Lee	182	.9	97	1.4	4	.3
Manatee	277	1.3	230	3.4	4	.3
Marion	672	3.2	58	.9	14	.9
Orange	3,168	15.1	408	6.0	206	13.9
Osceola	259	1.2	49	.7	28	1.8
Pasco	853	4.1	170	2.5	43	2.9
Pinellas	495	2.4	498	7.3	38	2.6

CITRUS PLANTINGS IN FLORIDA—*Continued*

Polk	4,636	22.1	2,035	30.0	355	24.0
Putnam	286	1.4	26	.4	38	2.6
St. Lucie	832	4.0	487	7.2	54	3.6
Sarasota	168	.8	57	.8	1	.1
Seminole	411	2.0	49	.7	49	3.3
Volusia	796	3.8	92	1.4	154	10.4
Other Counties	1,029	4.9	301	4.4	97	6.5
Totals	20,937	100.0%	6,780	100.0%	1,482	100.0%
Approximate Acres	322.1		104.3		22.8	

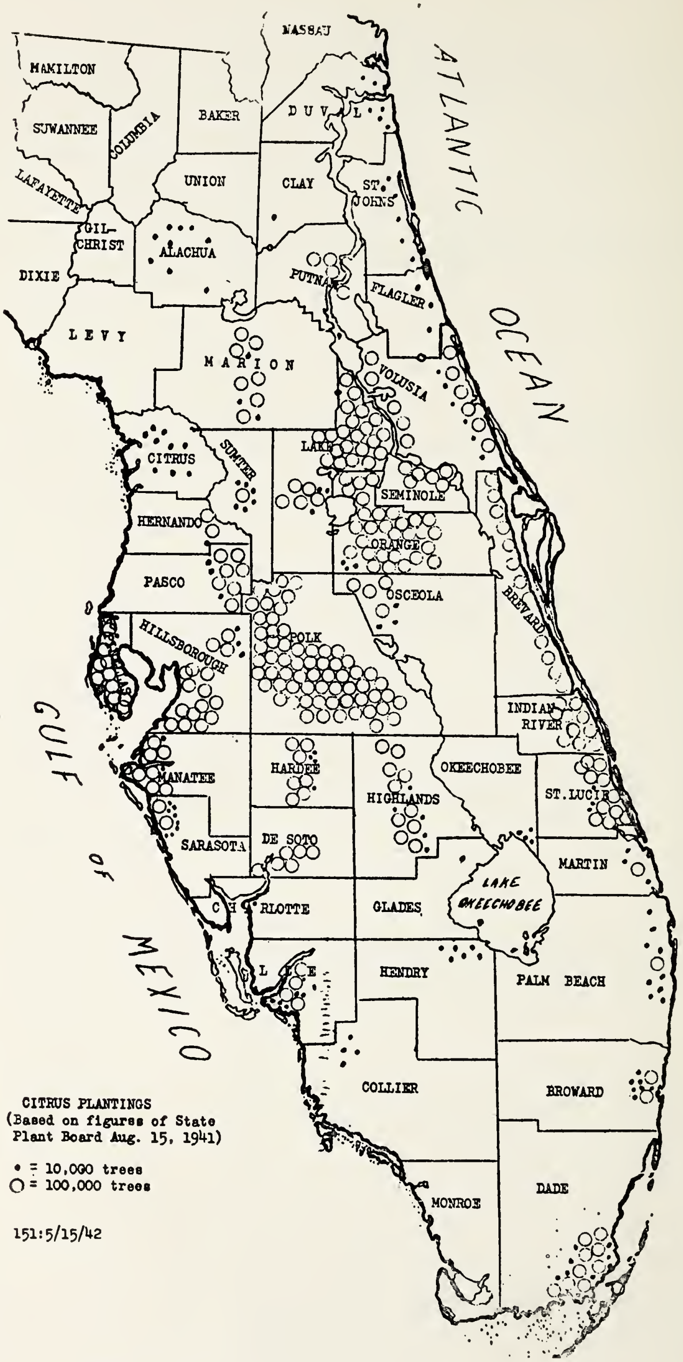

Fig. 1.—Distribution of commercial citrus in Florida.

suming centers. In a sense the citrus industry is more of a business perhaps than any other fruit industry, and this is in a large measure brought on by the fact that the areas in which it is grown are remote from the consuming centers.

The reasons for this amazing development of the citrus industry are many, one of the outstanding being

TABLE II—PRODUCTION OF CITRUS IN FLORIDA AND CALIFORNIA PRIOR TO 1910

(Taken from H. Harold Hume's "The Cultivation of Citrus Fruits")

Season	*Florida*	*California*
1886-87	1,260,000	840,560
1887-88	1,450,000	957,600
1888-89	1,950,000	1,067,040
1889-90	2,150,000	1,333,800
1890-91	2,450,000	1,541,280
1891-92	2,713,180	1,691,760
1892-93	3,450,000	2,255,680
1893-94	5,055,367	2,230,980
1894-95	2,808,187	1,908,360
1895-96	147,000	2,878,500
1896-97	218,379	2,793,000
1897-98	358,966	2,758,140
1898-99	252,000	3,933,380
1899-00	274,000	6,767,420
1900-01	352,600	9,156,860
1901-02	974,033	7,747,060
1902-03	1,147,491	8,921,220
1903-04	1,954,954	11,114,656
1904-05	2,961,192	11,559,542
1905-06	3,794,133	10,155,542
1906-07	3,801,101	11,388,029
1907-08	3,250,000	12,327,944
1908-09	4,634,000	15,460,912

TABLE III—CITRUS PRODUCTION IN FLORIDA SINCE 1911

	Crop Year	*Oranges—All (000 Boxes)*	*Tangerines (000 Boxes)*	*Grapefruit—All (000 Boxes)*
5.1	1911-12[1]	3,950		1,150
8.7	1912-13[1]	6,700		2,000
8.4	1913-14[1]	6,200		2,200
10.4	1914-15[1]	8,000		2,400
8.9	1915-16[1]	6,500		2,400
8.2	1916-17[1]	5,700		2,500
6.0	1917-18[1]	4,000		2,000
9.5	1918-19[1]	6,000		3,500
13.85	1919-20	7,550	1,450	5,900
15.2	1920-21	8,700	700	5,800
15.1	1921-22	7,850	550	6,700
18.7	1922-23	10,150	750	7,800
22.2	1923-24	13,150	550	8,500
20.2	1924-25	10,400	900	8,900
17.8	1925-26	9,500	700	7,600
19.6	1926-27	10,100	900	8,600
17.0	1927-28	8,650	850	7,500
27.8	1928-29	15,000	1,500	11,300
18.1	1929-30	8,950	850	8,300
35.0	1930-31	16,800	2,400	15,800
24.9	1931-32	12,200	2,000	10,700
28.0	1932-33	14,500	1,900	11,600
28.8	1933-34	15,900	2,000	10,900
32.8	1934-35	15,600	2,000	15,200
29.5	1935-36	15,900	2,100	11,500
40.2	1936-37	19,100	3,000	18,100
40.8	1937-38	23,900	2,300	14,600
56.6	1938-39	29,900	3,400	23,300
43.9	1939-40	25,600	2,400	15,900
55.9	1940-41	28,600	2,700	24,600
44.5	1941-42	27,200	2,100	19,200
68.7	1942-43	37,200	4,200	27,300
80.8	1943-44	46,200	3,600	31,000
69.1	1944-45	42,800	4,000	22,300
86.0	1945-46	49,800	4,200	32,000
87.4	1946-47	53,700	4,700	29,000
95.4	1947-48	58,400	4,000	33,000
92.9	1948-49	58,300	4,400	30,200
87.7	1949-50	58,500	5,000	24,200
105.3	1950-51	67,300	4,800	33,200
119.1	1951-52[2]	78,600,000	4,500	36,000

[1] Includes Tangerines.
[2] Preliminary.
Source: Division of Agricultural Statistics, Bureau of Agricultural Economics, and Florida Crop & Livestock Reporting Service.

TABLE IV—PRODUCTION OF CITRUS FRUIT IN CALIFORNIA, TEXAS AND ARIZONA

Crop Year	*Grapefruit—All*			*Oranges—All*
	Texas (000 Boxes)	*Arizona (000 Boxes)*	*California (000 Boxes)*	*California (000 Boxes)*
1911-12			64	15,273
1912-13			85	6,870
1913-14			107	19,688
1914-15			139	17,407
1915-16			159	17,147
1916-17			188	21,315
1917-18			227	8,267
1918-19			380	18,315
1919-20	3	29	363	16,632
1920-21	5	34	395	23,771
1921-22	8	35	360	14,021
1922-23	35	60	394	21,283
1923-24	65	95	363	24,153
1924-25	301	105	387	18,506
1925-26	200	150	600	24,200
1926-27	361	120	672	28,252
1927-28	524	176	720	22,737
1928-29	753	211	972	39,159
1929-30	1,550	365	1,000	21,195
1930-31	1,200	400	1,290	35,179
1931-32	2,600	450	1,431	34,658
1932-33	1,440	614	1,350	34,265
1933-34	1,200	800	1,772	28,439
1934-35	2,740	1,240	2,167	45,047
1935-36	2,780	1,800	2,267	32,809
1936-37	9,630	1,400	1,540	29,827
1937-38	11,840	2,750	1,943	45,914
1938-39	15,670	2,700	1,924	41,420
1939-40	14,400	2,900	1,992	44,425
1940-41	13,650	2,650	1,983	50,778
1941-42	14,500	3,380	3,181	52,155
1942-43	17,510	2,600	3,071	44,329
1943-44	17,710	4,080	3,300	51,961
1944-45	22,300	3,750	3,830	60,500
1945-46	24,000	4,100	3,350	44,010
1946-47	23,300	4,100	3,120	53,530
1947-48	23,200	3,000	2,430	45,830
1948-49	11,300	1,880	2,150	37,010
1949-50	6,400	3,400	2,500	41,860
1950-51	7,500	3,150	2,730	45,210
1951-52[1]	200	2,140	2,030	38,500

[1] Preliminary.

Source: Division of Agricultural Statistics, Bureau of Agricultural Economics, and Florida Crop & Livestock Reporting Service.

its availability in the winter when other fruits are not available in large quantities in the consuming centers in the North. Perhaps as big a factor is the fact that it has been featured in the thinking of people for many generations as a romantic fruit coming from distant lands with a little more glamour than the ordinary fruits of temperate climates. More recently, since vitamins have become a common topic in dietary discussions, its very high content of vitamins (particularly vitamin C) and minerals, has become one of the major reasons for its use in children's diets and for people in ill health. While many people today feel that its outstanding nutritional value is the main reason for its popularity, it should not be forgotten that it was popular before vitamins became a daily topic of conversation, and when the price was necessarily high due to costly methods of distribution. While it used to be only a fruit in the children's stockings at Christmas or fruit for some other special occasion, it is today a major article of diet for thousands of children and is no longer classed among the luxury fruits but rather among the staple fruits which are desirable for proper development of physical health in both children and adults.[1]

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[1] Those who are interested in a more detailed history of citrus are referred to **The Citrus Industry,** Vol. 1, by Herbert John Webber and Leon Dexter Batchelor.

Table V—Comparison Between Production of Citrus Fruits and Other Major Fruits in the United States

	1950		*1940-49 Average*	
	Boxes	*Bushels*	*Boxes*	*Bushels*
	Millions		*Millions*	
ORANGES				
Florida	67.3	107.7	46.1	73.8
California	44.8	62.7	48.2	67.5
Texas	2.7	4.3	3.6	5.8
Arizona and Others	1.8	2.5	.9	1.3
Total Oranges		177.2	98.8	148.4
TANGERINES				
Florida	4.6	7.4	3.9	6.2
GRAPEFRUIT				
Florida	33.3	53.3	27.3	43.7
Texas	7.5	12.0	17.4	27.8
California-Arizona	5.9	8.3	6.2	8.7
Total Grapefruit		73.6	50.9	80.2
LEMONS				
California	13.0	18.2	13.0	18.2
LIMES				
Florida	.3	.5	.2	.3
TOTAL CITRUS (Bushels)		276.9		253.3
APPLES (U.S. Production)		123.1		109.0
PEACHES " "		53.5		71.2
PEARS " "		31.1		31.0
Total other than Citrus		207.7		211.2

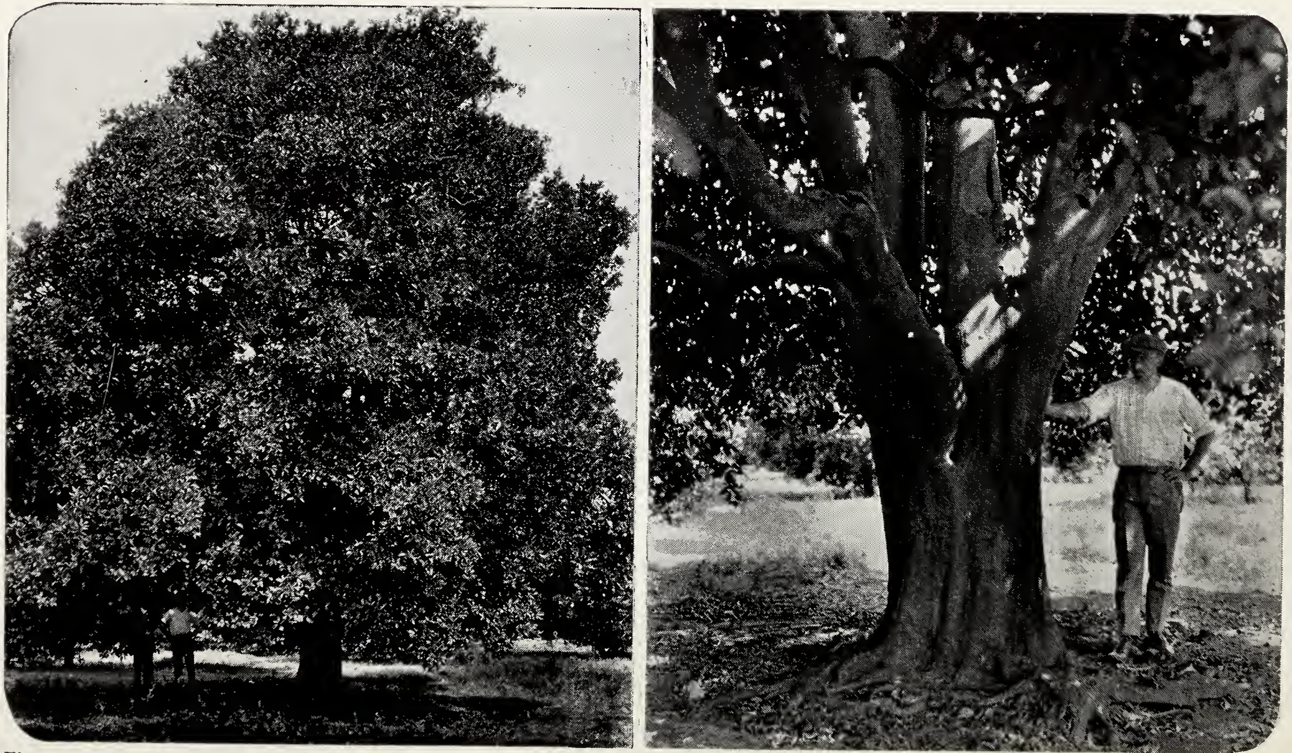

Fig. 2.—This orange tree, according to early history of the citrus growing industry, is the largest and oldest tree in North America. It is said that it is more than eighty years old and has successfully withstood the most serious and devastating freezes in Florida.

II.

Production Methods

CHOICE OF LOCATION FOR A GROVE

In selecting a location for a citrus grove there are a number of things that have to be considered with care if the grove is to be profitable. In the early development of the citrus industry of Florida selections were made largely on the basis of soil fertility because so little was known about the problems of cold protection. Owing to the disastrous effects of freezes, however, the emphasis today is mainly on warmth of location and natural cold protection rather than soil fertility. However, the soil is extremely important and the following general discussion of this problem is given in order that the prospective grower may be informed on the basic facts involved.

A. Soils

In the early development of Florida, soils were more or less classed in certain general categories having to do with the terrain and with the type of growth occurring on them, and 3 general types were commonly considered as follows:

(1) Flatwood Soils. These are the soils in the low, flat areas, usually underlaid with hardpan and on which there is a growth of pines and saw palmettos with occasional bayheads or small swampy places which usually produce a growth of cypress or similar water-loving trees. These flatwood soils are not generally used for citrus because the hardpan is too close to the surface and as a result the soil will either become saturated with water during the summer season or too dry during the dry season. There are a few exceptions, however, and these are the slightly higher places in the flatwoods where the hardpan is sufficiently far down to eliminate it as a factor in tree growth. The earliest developments on the flatwoods were associated with cattle operations, and these higher locations were the places where the cattle

pens were located and in which seedling citrus trees were planted as shade for the cattle and as a source of revenue. These favorable locations occurred chiefly in the following soil series: Scranton, Bladen and Coxville; with limited developments on Portsmouth, Leon, and St. Johns soils. These soils are naturally somewhat richer from a fertility standpoint than the high sandy soils which will be discussed later, but are frequently rather cold and drainage for excess water must be provided in most cases. In large areas of flatwoods a slight difference in elevation will result in a considerable increase in cold protection, and this is taken advantage of in locating groves in such areas. The flatwood soils are more often used for cattle grazing, or where the drainage is good, for truck crop production, and the planting of citrus on them in recent years has not been very extensive.

(2) HAMMOCK SOILS. Hammock soils are found where the original growth was predominantly hardwoods such as oak, hickory and magnolia; and in the coastal area cabbage palmettos are commonly numerous. It was in the hammocks that a great deal of the early development occurred and also where the sour orange grew to the best advantage. These lands are usually well supplied with organic matter and have a stable supply of moisture throughout the season. They have the disadvantage of usually being low and rather cold unless close to large bodies of water, and this tends to offset the higher degree of fertility. While there is a great deal of acreage on so-called hammock lands today, developments on these soils have not been extensive in recent years. Included in the hammock soils are the Gainesville, Parkwood and Orlando series and some of the better grades of Eustis and Lakeland (formerly Norfolk) soils. Mainly this classification of hammock soils is not a good one as far as soils are concerned because it is more of an indication of good moisture conditions and high organic matter content than it is an indication *per se* of a soil series or type.

(3) HIGH PINELANDS. These are the soils on which the greatest recent development has occurred. They are generally very light sands of low natural fertility on

which grew pines and the various types of scrub or black-jack oaks. The type of growth was to a considerable extent determined by the degree of fertility and varied from a heavy stand of pines to very few pines with a considerable growth of black-jack oaks. These soils are very well drained but have a very shallow top soil in which most of the fertility is concentrated and a very poor sandy subsoil. Underlying the sand is usually a clay subsoil but the depth at which it is found may vary from 20 inches to as much as 100 feet. When the clay is closer to the top than 12 feet, it may have considerable effect upon the value of the soil for grove purposes, but below that depth has little or no effect. The most common soil series in this group is the Lakeland (formerly Norfolk), which varies from a very coarse sand extremely low in organic matter (Lakeland Sand), commonly called "black-jack oak land," through Lakeland fine sands of varying degrees of organic matter content, commonly classed as high pinelands, to the Lakeland fine sandy loams which support hammock or hardwood growth. While the lighter Lakeland soils were not widely planted to citrus until comparatively recent years, they constitute the major soil series used for citrus today. This is not because of their fertility but because of their natural warmth due to their elevation and consequent good air drainage. Fertility is very low except on the sandy loam types, and trees are produced mainly by the application of fertilizers and sprays rather than by means of any natural fertility that is present in the soil. A somewhat similar soil that is closely allied with Lakeland and is found on the lower slopes and in knolls in the flatwoods is the Blanton soil, but instead of a yellow sandy subsoil, it has a very pale sandy subsoil splotched with gray to grayish yellow. Blanton soils are usually somewhat more difficult to handle as grove soils and frequently are a little less well located as regards cold protection. The Eustis soils on which pines were originally growing are somewhat similar in characteristics to Lakeland soils but are generally of higher fertility. The better grades of Eustis soils were mainly growing hardwoods rather than pine forests and belong in the hammock group.

Analyses of typical types are given in Table VI.[1] It will be noted that these soils, for the most part, are of much lower fertility than ordinary farm soils and instead of having their fine or colloidal material made up of inorganic clays, it is usually of an organic nature so that the maintenance of organic material in the soil is of extreme importance. In this sense, therefore, it may be considered that most Florida citrus soils are essentially organic soils whether they are mucks, which constitute a rather small acreage, or Lakeland (formerly Norfolk) sands, which constitute a considerable acreage, and which are made up of inert sand and a small percentage of organic matter that gives the soil most of its fertility characteristics. It will be seen from this that in the lighter soils the very low fertility makes fertilization a very critical matter since trees are grown not on the natural fertility of the soil plus a restricted amount of fertilizer, as in the case of many fruits, but almost entirely upon the constituents of the fertilizer, the soil playing only a role in maintaining these elements in a form available to the plant. Even this role is somewhat restricted by the very rapid leaching and the shallowness of the top soil.

In the selection of grove sites the question of cold protection must, of course, come first. Under conditions of equal cold protection, soil is important but it is possible to grow citrus on very poor soils from a fertility standpoint. Citrus will not stand waterlogged soils for any length of time, but can be grown on a very wide range of soils, varying from alkaline to acid and from heavy clays or mucks to very light sands.

B. Cold Protection

In selecting a location for a grove, cold protection is, of course, of primary importance, and this is not a matter

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[1] For those interested in further details on soils as such in the citrus area, the following bulletins will be helpful. Peech, Michael (rev. by T. W. Young), Chemical Studies on Soils from Florida Citrus Groves, Fla. Agr. Expr. Sta. Bul. 448; and Henderson, J. R., The Soils of Florida, Fla. Agr. Expr. Sta. Bul. 334.

TABLE VI—MINIMUM, MAXIMUM AND AVERAGE AMOUNTS OF VARIOUS CONSTITUENTS FOUND IN DIFFERENT CITRUS GROVE SOILS

Soil Series	No. of Samples	Depth		pH	Base Saturation %	Exch. Cap. m.e./100 g.	Pounds Per Acre-Six-Inches of Soil								Nitrate N	Total N %	Organic Matter %	Ratio: Ex.Cap. % O.M.	Ratio C:N
							Exchangeable Bases						P						
							Ca	Mg	K	Mn	Zn	Cu	Acid Sol.	Water Sol.					
Lakeland (formerly Norfolk)	55	Surface Soil	Min.	4.60	17.5	1.39	149	5	21	0.2	0.08	0.06	35	4	0	0.020	0.89	1.11	17
			Max.	6.59	100.	6.25	1240	121	270	17.	5.6	4.2	1840	29	77	0.073	3.10	2.39	34
			Aver.	5.56*	57.3	2.72	520	39	73	3.2	0.91	0.55	408	12	13	0.039	1.56	1.73	23
	55	Subsoil	Min.	4.29	7.0	0.68	20	1	8	0.0	0.08	0.04	6	0	0	0.007	0.42	1.17	15
			Max.	5.89	48.2	3.04	212	27	68	5.3	0.96	3.0	144	22	18	0.031	1.45	2.70	60
			Aver.	5.03	17.8	1.26	66	6	26	0.8	0.36	0.26	61	6	3	0.011	0.70	1.84	36
Blanton	6	Surface Soil	Min.	5.49	40.2	3.51	605	18	66	0.3	0.16	0.06	200	10	6	0.039	1.45	2.03	19
			Max.	6.19	75.0	4.70	1070	78	175	7.5	2.0	0.68	960	23	39	0.057	2.31	2.58	29
			Aver.	5.75	59.4	4.02	812	47	110	3.3	0.80	0.31	566	16	19	0.047	1.90	2.23	24
	6	Subsoil	Min.	4.49	7.6	1.70	40	2	31	0.1	0.16	0.04	40	2	0	0.010	0.65	1.64	31
			Max.	5.39	22.1	3.44	281	13	42	1.5	0.56	0.36	205	21	14	0.020	1.62	2.80	47
			Aver.	4.90	17.3	2.25	126	7	36	0.8	0.32	0.15	109	12	4	0.014	1.00	2.40	40
Eustis	5	Surface Soil	Min.	5.64	51.2	2.84	485	34	56	1.7	0.24	0.04	432	12	4	0.034	1.46	1.73	15
			Max.	6.39	89.5	6.46	1460	83	208	8.5	1.4	0.80	1480	18	15	0.067	3.18	2.22	31
			Aver.	6.04	71.5	4.17	1001	56	150	3.9	0.54	0.34	740	15	9	0.055	2.06	2.00	22
	5	Subsoil	Min.	5.00	17.1	1.56	81	6	28	1.0	0.16	0.04	58	0	2	0.011	0.58	1.70	16
			Max.	5.74	64.0	3.60	363	19	88	4.7	0.48	0.12	146	19	6	0.041	2.12	2.83	53
			Aver.	5.38	36.7	2.32	263	12	62	2.6	0.24	0.08	115	11	3	0.021	1.10	2.25	33
Lakewood	2	Surface Soil	Min.	6.00	77.5	3.24	880	54	73	0.7	0.08	0.12	397	15	8	0.057	1.67	1.94	17
			Max.	6.74	100.	5.65	2160	105	78	1.2	0.16	0.22	625	17	20	0.067	2.18	2.59	19
			Aver.	6.37	88.7	4.45	1520	79	76	0.9	0.12	0.17	514	16	14	0.062	1.93	2.27	18
	3	Subsoil	Min.	4.54	5.9	0.92	65	5	30	0.1	0.08	0.06	48	7	0	0.013	0.47	1.95	17
			Max.	6.04	33.9	2.61	532	34	57	0.1	0.40	0.10	248	13	4	0.017	0.86	3.04	31
			Aver.	5.37	19.0	1.66	233	15	44	0.1	0.24	0.08	131	9	1	0.015	0.68	2.35	26

* Arithmetical average of pH values rather than of the actual hydrogen ion concentration.

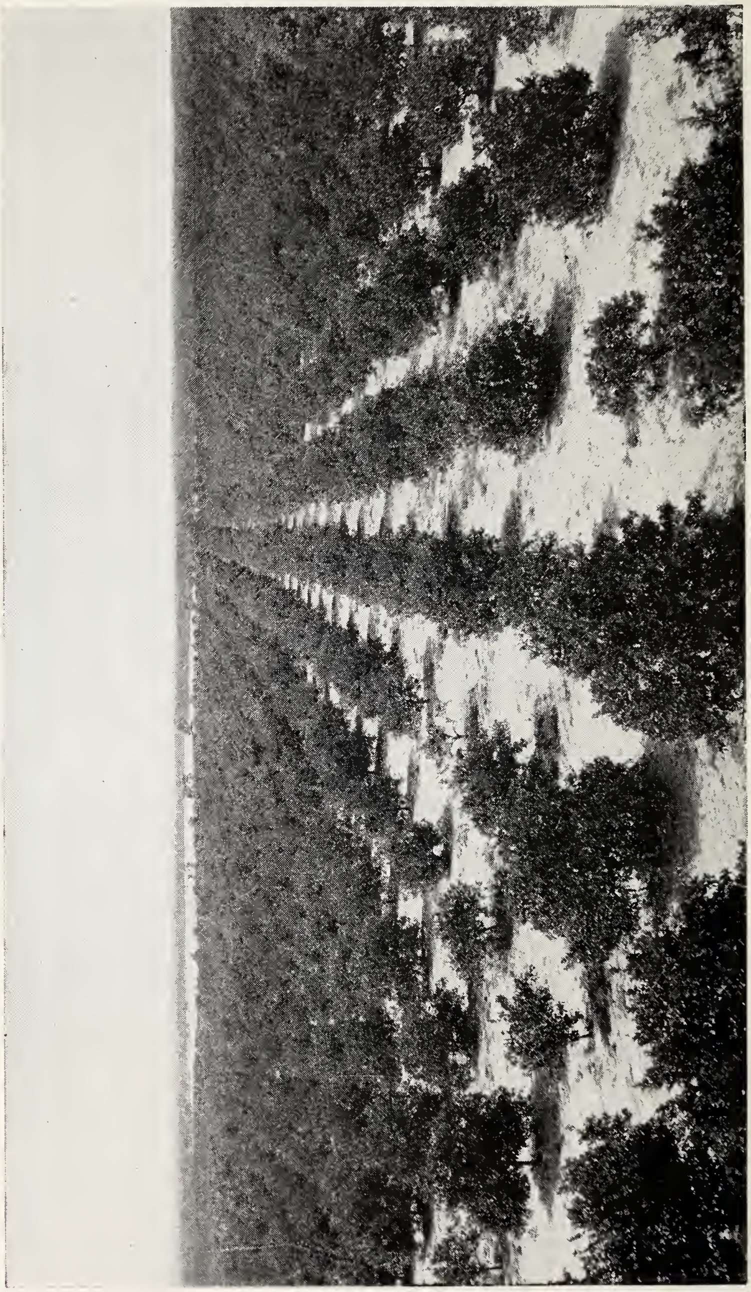

Fig. 3.—Portion of 5,000-acre grove.

that can be defined by zones within the state but rather must be determined on the basis of local conditions. The first criterion which must be considered is the matter of air drainage. Cold air develops due to the loss of heat from the soil by radiation to the upper atmosphere. The soil then cools the lower layer of air by contact or convection, forming a cold layer of air close to the ground. This cold air, being heavier than warm air, will drain downhill so that any location for citrus should preferably have adequate air drainage; that is, there should be adjacent low areas to which the cold air can drain as it is cooled by contact with the soil. The high dry sandy soils of the regions in central Florida lose heat rapidly on cold clear nights, but their elevation makes possible the drainage of the cold air to surrounding lower lands. The location consequently, should not be trapped or surrounded by higher areas which would prevent the natural drainage of cold air away from the grove location. Sometimes a location may seem to have good air drainage to a lower location, but if this lower area is surrounded by

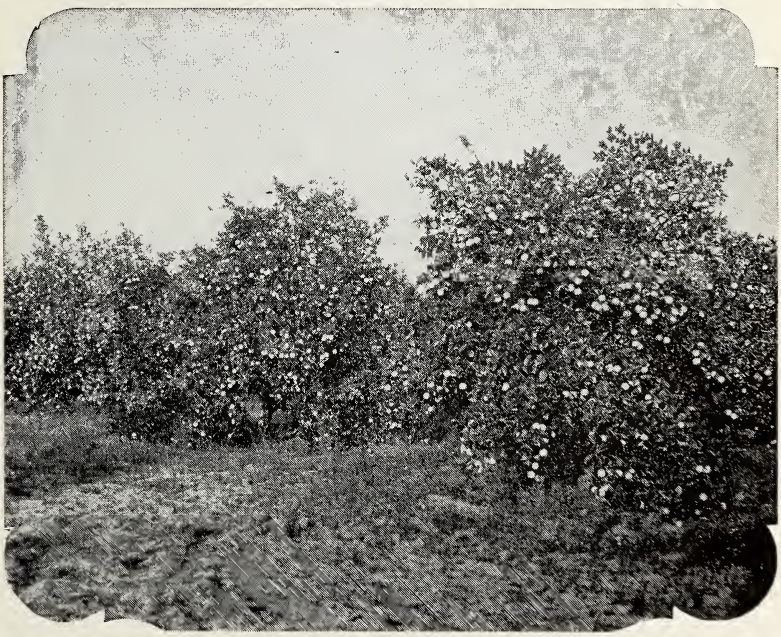

Fig. 4.—Trees grown on good citrus land with liberal fertilization and cultivation produce abundant crops.

a ridge to form a "lake" of cold air, then the location may be unduly cold. Very careful consideration should be given to determining whether a definite location has adequate air drainage.

Water protection is very important. Locations near the coast are valuable where the slope is to the water because of the moderating effect of the gulf or ocean on the land immediately adjoining. Large lakes are also a very excellent aid in cold protection, providing they are deep. Shallow lakes are likely to become very cold when cold winds of considerable duration are encountered and consequently do not give as satisfactory cold protection. The cold winds come from the northwest and north, and locations on the south and southeast sides of large lakes are particularly favorable as far as cold protection is concerned. Also, the amount of area in lakes in a given locality is important. One lake, even if fairly large, will not give a great deal of protection, but if in a district there are many lakes, constituting a very large percentage of the surface of the terrain, the cold protection is considerable. An examination of the map will reveal that citrus production in central Florida is to a very considerable extent concentrated in those areas which have a large number of lakes or are adjacent to the coast.

Information on prospective cold protection can usually be obtained from a history of the district under consideration, and particularly from the groves in that area. If there are a large number of groves which have been in rather steady production in spite of cold waves, the area is probably quite warm, but if only a few groves exist and these have suffered from cold, it is probably cold although some small areas may be warm. In addition to examining the topography, therefore, considerable attention should be given to investigating the past history of the old groves in the vicinity with regard to cold effects during major freezes, as this is one of the best guides to the relative cold protection in any area.

C. Nearness to Markets

In addition to considerations having to do with soils and cold protection, some consideration should be given to the matter of marketing fruit that is produced. Freight rates increase as the grove area becomes more distant from the northern market, and also it is easier to sell fruit that is produced close to large packing houses and good roads, than where groves are remote from good roads and more or less inaccessible to packing houses. In any selection of a grove location some consideration should be given to nearness to packing houses and canneries and to the reputation of the area as a profitable producing area. Groves located in areas where there are few packing houses and no canneries and where roads are bad for hauling will usually be less profitable and more difficult to handle than groves in areas where the supplemental facilities are good.

CITRUS STOCKS

When planting a new grove or buying a grove, the question of rootstock is an important one because the stock should be adapted to the particular soil on which the grove is located and also to some extent this selection is affected by the top variety and the type of market which it is proposed to use. Improper stocks may make a grove unprofitable because of poor production or slowness in coming into bearing, and in the case of some particular varieties may make for an inferior quality of fruit which will not be useful in a specialty market if such a market is to be used by the grower.

Considerable change has taken place in the attitude toward certain stocks due to the changes in tree nutrition which have taken place during the last 20 years, and this change in viewpoint has been so great with regard to rough lemon stock that it is now the most widely used stock, although a few years ago it was on the verge of being discarded. For this reason the notes below should be read with considerable care because they represent a change of viewpoint toward certain stocks which has been brought on by changes in fertilizer and spray practices within the last few years, while the older viewpoints were based on practices which are not now widely used. Susceptibility to disease has also become a controlling factor. Some further changes of viewpoint are likely to develop as the changes in fertilizing and spraying progress further, but the following notes will be found useful for

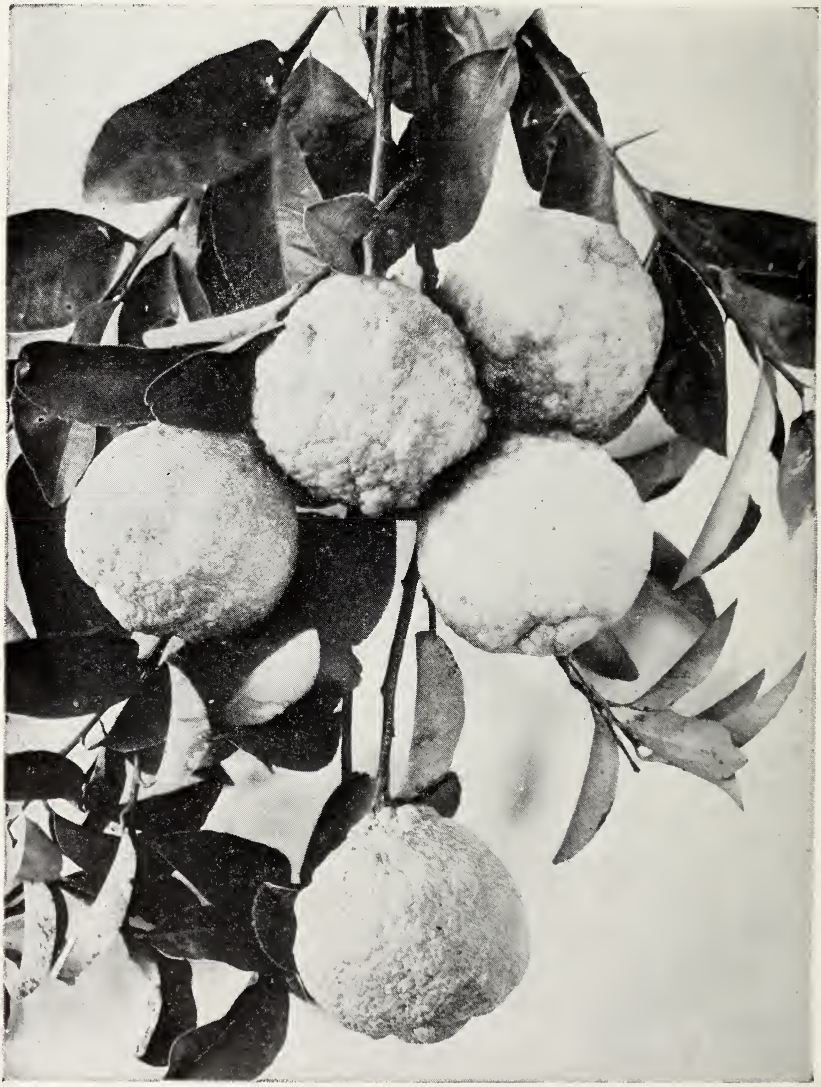

Fig. 5.—Rough lemon fruits and foliage.

those who propose to plant a new grove or buy a grove already planted.

A. Rough Lemon Stock (*Citrus Limon* (Linn.) Burm. f.)

This is the most widely used stock in Florida citrus groves at the present time, although it did not come into extensive use until sometime between 1905 and 1910. It gained its original popularity because it would produce a tree very quickly on the light sandy soils of the higher ridges, which soils had not been used to any extent prior to its introduction because of the slowness with which stocks formerly used would produce trees on such light soils. These soils, because of the warmth of their location, offered the possibility of eliminating a great deal of the freeze hazard in Florida citrus growing, and when a stock was found that would grow trees quickly on such soils a tremendous development resulted. The stock was particularly adapted to nursery work because it grew so well and could be budded with great ease, and produced a satisfactory nursery tree in a relatively short time. Also, in large scale grove developments, trees budded on it grow very rapidly and come into bearing at an early age. For this reason, it was particularly well adapted to promotional development where it was desired to make a showing as soon as possible.

As the groves on the light sandy soils came into bearing, however, numerous difficulties developed, including a tendency for the trees to bear in alternate years and to have a heavy loss of leaves during the year when a heavy crop was being carried by the trees. Also, the quality of the fruit was inferior, the fruit tending to have a coarse, thick skin and to be lacking in flavor. In oranges the color was very poor. This difficulty was blamed on rough lemon stock as such and for a number of years a search was conducted to find a substitute stock without success. With the development of the use of the so-called minor elements, it was found that much of the trouble with rough lemon stock was due to mineral deficiencies, and when these were corrected, difficulties in maintaining the trees in good condition disappeared and the quality of fruit showed very great improvement. While it is still possible to produce a better quality of fruit on sour stock under comparable conditions of soil and fertilization, the very heavy bearing of rough lemon stock, plus the fact that fruit on properly fertilized trees on rough lemon stock is only slightly inferior to that on sour stock, has resulted in a general return to favor of this stock. This is understandable in view of the fact that it brings trees into heavy production earlier than any other stock so far used and is the only stock that will produce large yields on very light sandy soils. Also, it is tolerant to tristeza, which is a big factor in its favor. At present, rough lemon stock is recommended for all light sandy soils and for all varieties of fruit grown on such soils with the exception of tangerines, tangelos, and other similar specialty fruits when these are to be grown exclusively for the fancy fruit market. It is not recommended for any wet soils because it will not stand waterlogging of the soil for any appreciable length of time; and because of its susceptibility to foot rot. In cases where soils are marginal between heavy hammock and light sandy soils and where the soil is well drained, preference should be given to rough lemon stock because of its heavy production, its ability to withstand drought and its tolerance to tristeza.

B. SOUR OR SEVILLE ORANGE STOCK (*Citrus Aurantium,* Linn.)

The second most widely planted stock in Florida is sour orange, and this is also one of the oldest stocks on which budded groves have been grown. As previously mentioned, the sour orange was widely spread by the Spaniards and Indians throughout Florida, and many wild sour orange groves developed in hammocks. Some of the very early budded groves were produced by budding these wild sour orange trees in place in the hammock, and these groves were called natural groves. Later the sour or Seville orange was promoted widely as a stock because of its great resistance to foot rot and the very fine fruit which it produces on heavy soils with a good supply of moisture. It produces a very fine quality of fruit and under favorable conditions fruits at an early age and gives very satisfactory production. It is not adapted to very light sandy soils but will withstand a great deal of waterlogging of the soils and has been in the past generally recommended for heavy soils.

The use of sour orange as a rootstock has received a severe set-back because of the disease known in Brazil as "tristeza," in Spanish speaking countries as "podredumbre de las raicillas," and in California as "quick decline." This disease, which is caused by a virus, stunts or kills oranges, grapefruit, mandarins and limes budded on sour orange stock. Up to the present time, it is known to occur in Java, South Africa and the South American countries of Argentina, Uruguay, Paraguay and Brazil, and it has caused the loss of several million trees in the last twenty years in these countries. In California, losses have been considerable and there is some indication that the disease, known there as "quick decline," may be a slightly different strain of the virus from the one present in South America. Recently it has been found in Florida, though the strain of the virus present in Florida appears to be less vigorous than the strain found in South America.

Because of the occurrence of tristeza in Florida, it is not advisable to use sour orange as a stock and this presents some difficulty because we do not have a really satisfactory substitute for the wet, heavy soils.

C. SWEET ORANGE STOCK (*Citrus sinensis,* Osbeck)

This stock was extensively used early in the history of the citrus industry but was largely discarded because of its susceptibility to foot rot and also because of the slowness with which trees budded on this stock came into bearing. In recent years it has been revived as a stock in the search for a substitute for rough lemon, and considerable planting was done in the early '30's on this stock on light sandy soils. With the change in fertilizer practices, however, it has largely been discarded because it is not well adapted to light sandy soils, suffers considerably from drought, and trees budded on it are slow in coming into bearing. The quality of fruit borne on trees budded on this stock is excellent, but the pro-

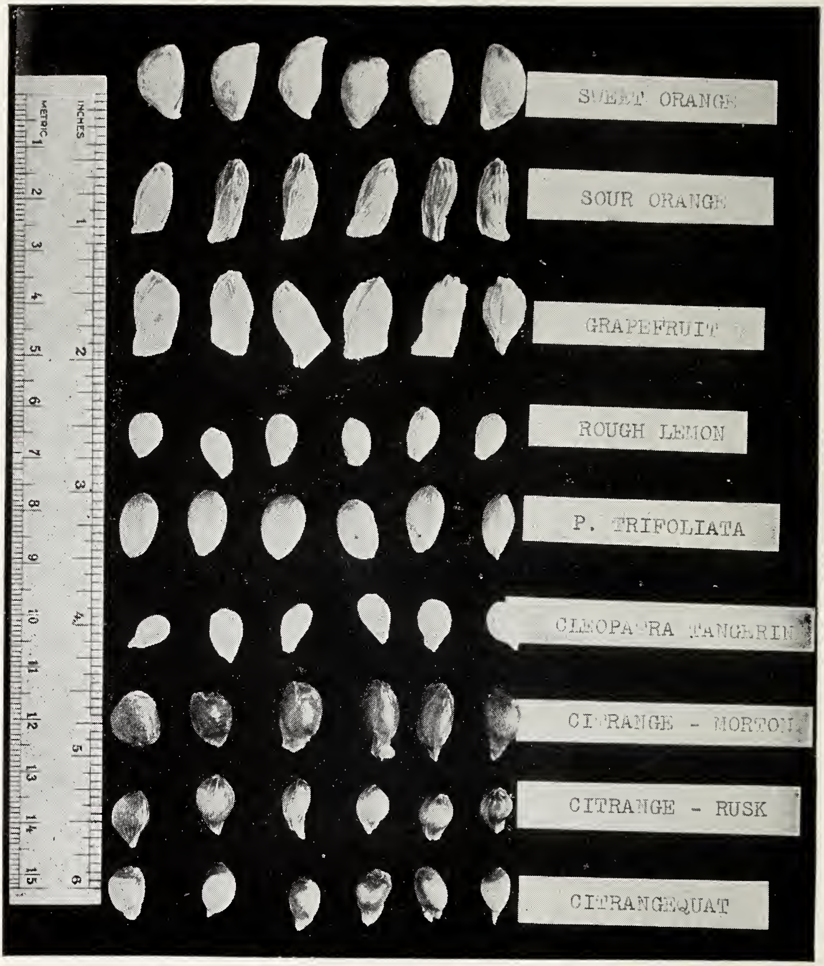

Fig. 6.—Seeds of various species of **Citrus** and **Poncirus.**

duction does not compare favorably with that of rough lemon, particularly in young trees, nor does its resistance to drought on light sandy soils compare favorably. It is not used on heavy soils because of its susceptibility to foot rot. It is used to some extent on intermediate soils as a stock for specialty fruits where quality is important, but is generally considered inferior in this regard to sour orange stock.

D. Cleopatra Stock (*Citrus reticulata* Blanco)

Cleopatra mandarin as a stock was first introduced as a stock a good many years ago and rather extensive plantings were made in the '20's and early '30's in an effort to get away from the poor condition of citrus groves on the sand hills. This poor condition, however, turned out to be due to mineral deficiencies rather than to the stock as had been supposed. Cleopatra mandarin is a very vigorous grower, has more resistance to foot rot than sweet orange or rough lemon, stands wet lands reasonably well, but trees budded on it are slow in coming into bearing and in this regard it is similar to sweet orange stock. In general, the quality of the fruit is very good and better than that produced on rough lemon stock and equal to that produced on sweet orange and probably on sour orange. The size of its fruit tends to be small, which makes it a poor stock for early varieties because size here may be important. Valencias budded on this are reputed to be very poor producers, but there are old blocks of trees of this combination in the State which have produced comparably with sour orange stock for many years, though they never produced quantities of fruit comparable to the possible production on rough lemon stock. With our present knowledge, it looks like one of our best possibilities for the replacement of sour orange on heavy, wet soils, but a poor stock for light sandy soils. It is being increasingly used and has been particularly satisfactory as a stock for Temple oranges and mandarins.

E. Trifoliate Orange Stock (*Poncirus trifoliata,* Raf.)

The trifoliate orange is used chiefly as a rootstock for Satsuma oranges and kumquats. It is deciduous and highly resistant to cold. Seedling trees of this species are very thorny, and are relatively slow growers. The addition of the evergreen top by budding, however, appears to increase the vigor of the root system although there is frequently some stunting of the top. Outside of the northern portion of the state, where it is used extensively for Satsumas on account of the cold hazard, it is very little used except as a stock for kumquats, although some of the older groves have other varieties budded on it. Generally speaking, it is probably much better adapted to the northern section of Florida than to the central and southern sections. Fruits from trees budded on this rootstock are usually of a very excellent quality and have a particularly smooth skin.

F. GRAPEFRUIT STOCK (*Citrus paradisi,* Macf.)

Grapefruit was used as a stock to a considerable extent several years ago but is very little used at present. Its use was probably the result of observations as to the vigorous growth of seedling grapefruit trees. In many cases on lighter soils it has proved unsatisfactory as a stock due to difficulty in getting trees budded on it to bear properly. On the heavier soils this may be overcome, at least partially, by increased fertilization, but on light soils this has not been very effective. It is less cold resistant than sour or sweet orange. Trees budded on it are susceptible to serious injury by the tristeza virus, so it can not be recommended for use.

G. MISCELLANEOUS ROOTSTOCKS

Commercial lemon is frequently found as the rootstock of occasional trees in groves presumably budded on rough lemon. The seeds in these cases probably were mixed accidentally with the rough lemon seed, as it is not considered to be a desirable rootstock due to its lack of disease resistance and the short life of trees budded on it.

At present a number of hybrids such as the citranges are being tried as rootstocks. A number of these hybrids exceed the trifoliate orange in vigor and make satisfactory unions, but it will take some time to determine their suitability in other respects. The Troyer citrange has shown great promise in California and it is now being extensively tried there and some trials are also being made in Florida. It is too early to determine its future possibilities, but it does show considerable promise. Supplies of seeds in commercial quantities for growing rootstocks are not available as yet in Florida.

VARIETIES

Innumerable varieties of citrus have been developed in Florida, but there has been a tendency to standardize on fewer varieties in the last 30 years so that today new plantings are limited to relatively few varieties. Most of the older varieties are now shipped with the modern varieties which are most nearly like them and not under their original name. For this reason only a few varieties will be described, and those wishing to study the earlier varieties can consult "The Cultivation of Citrus Fruits" by H. Harold Hume for a check list of the other varieties. No attempt will be made in this bulletin to give technical descriptions of varieties but mainly to outline their outstanding characteristics.

Varieties of oranges fall into three general classes: Early varieties which will pass the maturity test, provided by law, during the latter part of October and November; midseason varieties which are shipped during December, January or February; and late varieties which are ready for shipment about March 1st and are shipped up to early summer. Grapefruit varieties are less well defined as to season but were formerly classed as early and late varieties, although this classification has been largely done away with through the shipping of Marsh Seedless during the early season. There is not in grapefruit the distinct seasonal ripening that is recognized in oranges. A description of the standard commercial varieties is given below:

Oranges

EARLY VARIETIES

PARSON BROWN is one of the older varieties, originating about 1878 in a seedling grove at Webster which belonged to Parson Brown. It was widely planted following the freezes of 1894 and 1895. The fruit is of relatively large size, has 10 to 19 seeds, and a fairly coarse textured flesh and a deep yellow juice. The peel is slightly rough or pebbly, and tends to remain dark green rather late in the fall, although the color "breaks" easily in the coloring room. It is shipped mostly in October and November but under modern cultural practices has been found to carry well into December and January with improvement in quality during the prolonged period on the tree. The tree is very vigorous with a pronounced upright growth, easily grown and quite resistant to cold. This heavy producing, early orange is widely grown.

Hamlin is one of the newer early varieties. It originated in a grove planted in 1879 near Glenwood, Florida, but has been planted extensively only in recent years. It is a rather small orange, slightly oval, with a very smooth and fine textured skin, usually seedless, although 1 to 5 seeds may occur in occasional fruits. The fruit develops sweetness very early in the fall. When originally grown on rough lemon, the pulp tended to be dry and ricy, but this has been overcome by changes in fertilizing and spraying, and excellent quality fruit is now produced on rough lemon stock as well as on sour orange stock, and the fruit can be held through January if fertilization and spraying are properly carried out. The chief disadvantage is the small size of the fruit as compared with the Parson Brown and the very tender skin which is easily injured by sprays and adverse weather. This variety should never be sprayed with lime-sulfur during the summer or early fall months, as a burn may result that will seriously reduce the grade. Production is very heavy and the tree very vigorous but slightly more susceptible to cold than Parson Brown. It is the most widely planted early variety at present.

MIDSEASON VARIETIES

Pineapple is the most widely grown midseason orange and is usually round or slightly oblate with 12 to 20 seeds. It originated near Citra and has been planted more widely than any other midseason or early orange since the freezes of 1894 and 1895. It is noted for the very deep red color of the peel when fully ripe and the rich flavor of the juice. Production is heavy but, when not properly fertilized, the trees have a tendency to die back when a heavy crop is borne, with a consequent alternation in production. This characteristic can be completely overcome by proper culture. While it is probably the best flavored orange grown in Florida, its chief disadvantage is the heavy production of midseason fruit plus the fact that it contains 12 to 20 seeds.

Homosassa is a large midseason orange which was a selection from a seedling grove and is like the fruit produced by many of the early seedling groves in Florida. The fruit is usually large, orange-yellow in color but not orange-red, is usually round or slightly oblate, peel and flesh fairly coarse, but the flavor of the juice and pulp is exceptionally good; seeds 20 to 24. It has not been planted extensively in recent years because of its seediness but constitutes a very large acreage in Florida.

Jaffa is round to slightly oblong and is usually rather large in size with an orange-red peel. It was imported into this country from Palestine about 1885 and has been extensively planted on heavy soils. When attempts were first made to cultivate it on light soils it suffered excessively from so-called "blossom-end" or stylar-end rot. This seems to have been overcome to a considerable extent in recent years and considerable acreage has been planted within the last few years. The fruit has an excellent flavor with abundant deep orange-colored juice and only 6 to 9 seeds. It usually passes the maturity test a little earlier than the Pineapple but will hang on the trees satisfactorily throughout midseason. The tree is very vigorous with a peculiar upright habit of growth in which the branches tend to be upright rather than lateral or nearly lateral as in other varieties. The leaves are also more thickly placed on the twigs with a peculiar form of overlapping which tends to distinguish it from other varieties. The tree is very resistant to cold. Plantings have been increased during the last few years.

Seedlings. In the early history of Florida, citrus production was based very largely on extensive seedling groves, and while no considerable acreage of seedlings has been planted for many years, the seedling groves that are still in existence furnish a very substantial portion of the tonnage of fruit. The fruit is usually large with a smooth rind which is slightly more loose in relation to the pulp than is characteristic of most budded varieties. The acid and sugar content of the fruit is high and the juice of excellent quality, the number of seeds varies but is usually 20 or more per fruit. Seedling groves are very heavy and consistent producers until they are neglected and start to decline. While it is unlikely that any considerable additional acreage will be planted, they still constitute a very considerable portion of the midseason shipments.

Temple. The Temple is listed here because it is usually shipped as an orange, although it is probably a natural hybrid between a sweet orange and some variety of mandarin. The original tree was found on the old Temple property at Winter Park and was first introduced to the trade by the Buckeye Nurseries in 1917. It is an oblate orange, usually tapering slightly to the stem end; medium in size, has a deep red color in the rind and a deep orange-colored flesh, and about 20 seeds. The flavor is different from that of the ordinary sweet orange, and the pulp and juice have a pronounced aroma. The peel is usually thin and may be smooth or pebbly depending upon the fertilizer program and rootstock; it separates more easily from the pulp than is characteristic of most Florida oranges but not quite so easily as the tangerine. It is the finest orange in Florida for eating from the hand. Its season is slightly later than the ordinary midseason orange with the first fruits usually going to the Christmas market but the best quality being attained from January to March. The tree is slightly dwarfed with a very round top. It is more susceptible to cold than the ordinary orange and grapefruit varieties, and plantings should be limited to warm locations. This variety is extremely susceptible to variations in soils, fertilization, and rootstocks, and in order to obtain superior quality must be carefully fertilized and sprayed. When first introduced and planted widely on rough lemon stock, it became known as a very inferior fruit. This has been overcome by proper fertilization and spraying, but the variety is probably more susceptible to changes in quality due to improper fertilization than any other variety grown. In recent years plantings have been considerably increased and will probably continue to increase.

LATE VARIETIES

VALENCIA has been the standard late variety for many years, although it is probable that several slightly different strains of the Valencia have been involved. There were at least two original introductions into Florida in the early days. One of these was known as Hart's Late or Hart's Tardiff, and came through an English nursery. The other came from California but was probably from the same source as the introductions originally made into Florida. The Valencia is usually slightly oval, medium to large in size, with a deep orange color when fully ripe and an orange-colored flesh. Seeds are usually few and seldom over 6, and the juice is of very excellent quality. It is now shipped from March to July and with the improved fertilizer practices the season can be extended into the summer. The tree is vigorous and quite resistant to cold, and does well on most combinations of stocks and soils. It constitutes the main crop of late oranges in Florida. It is the variety most preferred for making frozen concentrate.

LUE GIM GONG. This orange is one of the newer late varieties, and was introduced about 1912. It was originally thought to be the result of hand pollination of the Valencia with pollen from the Mediterranean sweet by a Chinese, Lue Gim Gong, who resided near DeLand, but was probably only a nucellar seedling of the Valencia. The variety has been claimed to be somewhat superior to the Valencia, with more cold resistance in the tree and somewhat better color of fruit and with a longer season, but as grown commercially it has been impossible to separate it from the Valencia. The fruit is large and oblong, contains about 6 seeds, and the flesh is a deep orange color and of good quality. The season is the same as that of the Valencia.

MISCELLANEOUS VARIETIES

While there are a great many varieties similar to those already described and which have been planted at various times, they will not be discussed in detail here because they are no longer commercially planted. Some varieties which are slightly different from the standard oranges, however, are of interest. Most of these fall in rather definite classifications which will be discussed briefly below:

BLOOD ORANGES. These constitute a group of varieties in which blood-red streaks develop in the flesh, sometimes as very fine markings on the segment walls and sometimes as definite red blotches in the segments. The amount of red is related to some extent to the weather conditions and is more pronounced in cool winters. These are no longer extensively planted but constituted a considerable acreage at one time. Of the varieties planted, the Ruby Blood is most extensively grown. It is a small to medium, round to oblong orange; the color of the peel in midseason is deep orange-red to red. The pulp is of very fine grain, of excellent quality and streaked with red in midseason; seeds, about 11. The amount of blood marking is related to low temperatures and in warm winters there may be no markings at all. It has been shipped as an early orange but usually is classified as a midseason orange. Its quality is very superior but it is frequently discriminated against on markets which are not familiar with the red marking, and in recent years has usually been shipped before the red markings developed. Other blood orange varieties which have been planted to some extent are the Maltese, Saul's Blood, and St. Michael. Blood oranges are seldom planted at present but are interesting as dooryard varieties for those who wish unusual fruits of fine quality.

NAVELS. The Washington Navel has never been very satisfactory in Florida, although it is a standard commercial orange in California. In Florida it has a tendency to have a dry pulp, and in wet seasons when vegetative conditions are favorable may never be juicy. Because there is a demand for Navels, various attempts have been made to collect strains of Navels which would fruit well under Florida conditions. One of the early strains of this type is the Surprise Navel which is a medium-sized early Navel with a navel that usually does not protrude.

It has been very little planted but probably more so than any other variety of Navel in Florida up to recent years. At present a considerable number of new varieties of Navels have been selected and are being planted in a limited way. Some of these appear to have promise, but it is still too early to determine definitely their commercial value. Most of them are seedless or nearly seedless, ripen early, and run from medium to large size. Under favorable conditions, they are of excellent quality and have been sold extensively on the fancy fruit market. The peel is usually thick with a very smooth external texture, and the fruit is particularly good for eating from the hand as the pulp holds together better than that of most Florida oranges.

Grapefruit

The original seedling grapefruit groves in Florida produced fruits with a large number of seeds, and innumerable selections of varieties have been made from these groves in which the number of seeds varies from 30 to 60 per fruit. Unfortunately, these varieties have not been very clear-cut in their characteristics, and considerable carelessness has developed in their classification and segregation in groves so that it is difficult to be certain of the origin of the strain in any particular grove. The Duncan was one of the earliest of these, and this name is widely used today for budded seedy grapefruit, and while it was evidently a distinct variety in the beginning, its distinction has been very largely lost through the application of the name to many other strains. Other varieties which at one time were extensively planted are the Walters, Silver Cluster (Hall), McCarty, and Excelsior, but the differences between these varieties were insufficient to make classification certain and the names used by owners to classify the varieties in their groves are not always in strict accordance with the original descriptions. For that reason there is more and more of a tendency to classify seedy grapefruit as "Florida common" or "Duncan" and to omit the use of other varietal names, because classification of the fruit after it is picked is impossible under present circumstances. The name

"Duncan" is now used by most packing houses to cover all seedy grapefruit and about the only seedy grapefruit that has any separation as a distinct variety at the present time is the McCarty, but even here the name is used to cover other strains besides the original one. For that reason no attempt will be made here to separate the various seedy varieties which usually contain from 30 to 60 seeds, are usually oblate in shape, though the shape varies with fertilization and cultivation conditions. The tendency to bear fruit in clusters, which has been used to classify fruit of certain varieties, is now known to be controlled to a considerable extent by nutrition as the same strain will bear mostly in clusters under one type of fertilization and mostly separate fruit under another type. The varieties which are different from these seedy varieties are described below:

FOSTER. The Foster is a pink-fleshed sport of the Walters grapefruit, and like the Walters has a large number of seeds, about 55 to 60. It has a deep pink flesh with a pronounced blush on the outside of the fruit. It has been planted to some extent in Florida as an early grapefruit, but recently has been almost discarded because of its seediness.

MARSH or MARSH'S SEEDLESS. This variety was introduced by C. M. Marsh, Lakeland, Florida, in 1895 or 1896, from a seedling tree growing in Lakeland, Florida. It is nearly seedless, usually having only 2 to 8 seeds; fruit is usually oblate and pronouncedly flattened at the ends; pith in the center of the fruit, slightly open. Trees are very vigorous growers and heavy producers, resistant to cold and drought and less susceptible to variations in fertilization and spraying than most varieties of citrus in Florida. The chief advantage of the fruit on the market is its seedlessness, as it characteristically contains less sugar and acid than seedy varieties. It is widely planted and is favored on the market because of its seedlessness, though it is not so satisfactory for canning because of the lower sugar and acid content of the juice and the tendency of the segments to fall apart when used for sectionizing. It was originally introduced as a late fruit but is now sold extensively even in early season, and in recent years there has been more and more of a tendency for it to be shipped to the fresh fruit market and for the seedy varieties to be used in the canneries.

Thompson or Pink Marsh. Two strains of Marsh in which the flesh is pink instead of the characteristic light yellow were discovered many years ago, by W. B. Thompson in Florida in 1913 and by L. V. W. Brown in California about 1919. Both of these strains are typical Marsh fruit except for the pinkness of the flesh. The Thompson strain, commonly known as Pink Marsh Seedless, was extensively planted in Florida at one time but many of the original groves have now been top-worked to the ordinary varieties because the pink color does not show through the peel as is the case with the Foster described above. However, a revival of interest in pink meated grapefruit has caused a renewal of interest in this variety in recent years.

Red-Fleshed Grapefruit. In recent years, in Texas, sports of the Pink Marsh Seedless have been found in which the flesh is a deep pink to red color which shows through the peel in a pronounced "blush," particularly where fruits touch other fruits or leaves. Most widely known of these is the Ruby but a number of others have been discovered and Webb's Red Blush is now more widely planted in Texas than the Ruby. In Florida the Ruby has been planted and also some other strains, including the Glenn Red. These varieties are similar to the Marsh Seedless and the Pink Marsh in size and texture, but have the advantage of a deep red flesh plus enough color on the outside to distinguish them in the stores so that the customer can make a selection of the desired variety. They tend to be a little low in solids and have difficulty in meeting the maturity standards and the trees are subject to rather severe attacks by insects. Rust mites in particular seem to prefer them to Marsh Seedless and a somewhat similar phenomenon has been experienced in Texas. This variety is grown primarily for the fresh fruit market and not for canning or processing. Small sized fruit has been one of the major difficulties and also the pest control problem mentioned above, as well as the maturity problem, but as more information is available on handling these varieties, they will probably take a large and very definite place in the grapefruit picture in Florida.

Mandarins

In this group are included a number of varieties of what are commonly termed "kid glove" oranges because the skin fits rather loosely on the fruit and is in most varieties of a fine, smooth texture. Without attempting to classify these into various groups botanically, a few of the important varieties which are grown commercially are listed below:

DANCY TANGERINE. This is the principal commercial variety of this group in Florida and has been widely planted throughout the state. The fruit is oblate in shape, usually about 2¾ to 3 inches in lateral diameter, deep orange-red to red in color. It has a nippled base, 11 to 14 sections and usually about 14 seeds, although the seeds may vary widely in number. The skin is smooth and loose from the pulp, and as the fruit gets riper the pulp sometimes becomes entirely separated from the peel, a condition referred to in the trade as "puffiness." The pulp is very tender and the flavor rich, with a very definite aroma, somewhat spicy. The tree is round-headed with somewhat willowy branches so that under heavy cropping it sags down badly, and unusually heavy crops may result in a great deal of splitting in the crotches. Generally, it is a very heavy bearer with a tendency to produce too many small fruit. This variety is commonly known as the tangerine rather than the mandarin.

There are a large number of other mandarin varieties, including the Oneco, Warnurco, Clementine and Cleopatra, the latter having been used mainly as a rootstock.

SATSUMA. The Satsuma is really a group of varieties of Japanese origin and is much like the Dancy tangerine in shape and appearance except that it is not so deeply colored. The peel is also thicker and coarser, and the pulp is not so sprightly in taste nor does it have the spicy character of the Dancy tangerine. It reaches edibility much earlier in the season than the tangerine. The Satsumas are much more cold resistant than other commercial varieties of citrus and have been planted in the northern part of this state, in Alabama and Louisiana, but are very little grown in the main citrus belt in Florida. The fruit is usually about 3 inches in diameter, yellow to orange-yellow in color, the rind fairly thick and rough but loose from the pulp as in the tangerine, seedless to 4 seeds and seldom more than the latter number. Trees are of dwarf habit, tending to have somewhat willowy growth, and very resistant to cold. The common variety is the Owari.

KING. The King orange is of oblate shape and appears to be a large tangerine, the lateral diameter frequently being 3½ to 4 inches. The color of the fruit is deep orange when fully ripe, and the base around the calyx is usually somewhat roughened and creased. The peel is thick and very rough but loose from the pulp so that the fruit may be readily peeled. The flavor is good, more like an orange than a tangerine, and the seeds usually number about 20. The tree has a peculiar, upright, straggly growth and when full of fruit the long upright leaders bend over, giving a weeping appearance to the tree. It is not very extensively planted but is sold as a specialty fruit.

Limes and Lemons

While limes (*C. aurantifolia* Swingle) and lemons (*C. limon* (Linn.) Burm. f.) do not belong to the same species botanically, they are discussed together because commercially both fall in the category of acid fruits. At one time there was considerable production of lemons in Florida, but due to diseases and adverse weather conditions, the growing of lemons has disappeared except for a few trees in dooryards, while the production of limes has increased because they are better adapted to the climatic and soil conditions existing in Florida. Lemons are extensively produced in California and constitute the main supply of acid citrus fruit for the trade. No discussion of lemon varieties will be given here beyond mentioning that the Villafranca is the variety most commonly grown for home use. These need to be sprayed at frequent intervals with copper sprays to obtain fruit of good appearance. There are two varieties of limes commonly grown and these are described below:

KEY. This is a small acid lime commonly grown throughout the West Indies and is known by various names, the Key lime in Florida, the Mexican lime in Mexico, the Dominican lime in Dominica, etc. It is a small, seedy lime, almost round, with a slight nipple, seldom over 2 inches long and commonly smaller. The color is a very light green to lemon yellow. The skin is very smooth, the nipples are usually very short and small, and the base is very slightly elevated where it attaches to the stem. It has about 10 sections with very thin section walls and none to several seed, usually the latter. The juice is very excellent in flavor and very acid, usually containing 7 to 8 percent citric acid. The tree is bushy and usually not over 10 to 15 feet high, heavily covered with spines and having a more or less everbearing habit where cold weather does not interfere. It was at one time grown extensively on the Florida Keys south of Miami and on the Keys along the gulf coast of Florida, but has not been very satisfactory on the mainland because of sensitiveness to cold and diseases that disfigure the fruit. Some varieties have been described but in the main it is a collection of seedlings that are more or less alike, and no particular varieties are planted commercially, though several have been described and named.

TAHITI OR PERSIAN. This is a large oval lime, commonly 3 inches long, shaped much like a lemon, with a very smooth skin, green pulp, and almost always seedless. The juice is very acid and of excellent flavor. The fruit is picked while it is green, since it has a physiological trouble called stylar-end rot which affects the fruit when it starts to turn yellow. The trees are dwarf, 12 to 15 feet in height, and somewhat droopy. This variety is grown extensively on the Florida mainland, and the acreage has been increasing steadily during the last few years. The trees are harder to grow than orange or grapefruit trees, being more susceptible to gum disease that may be caused by either of two fungi, *Diplodia* or *Phomopsis.* These fungi cause considerable loss of trees. The acreage in warm locations has been on the increase, however, and extensive production of this lime now exists. The main season is late summer and fall, and it is commonly grown on rough lemon stock.[1]

Due to the recent development of lemon and lime concentrate for the making of lemonade and limeade, there has been a great revival of interest in acid fruits in Florida. In this product, the lemon or lime juice is concentrated, sugar and oil added and the product frozen. It is mixed with water to produce a lemon- or limeade as the case may be. There are indications that this market will be good enough to support a considerable lime or lemon industry in Florida and there is great interest in expanding the field of production of acid fruits at the present time.

Hybrids and Miscellaneous Varieties

TANGELOS. Tangelo is the name given to hybrids between tangerines and grapefruit, although crosses between tangerines and oranges and tangerines and Satsumas are frequently included in the group. There are a considerable number of these that have been developed by the United States Department of Agriculture, the two most common being the Thornton and Sampson tangelos.[2] At one time the Thornton was produced commercially, but the Sampson has never been popular because of its very acid flavor. Both of these varieties are susceptible to lemon scab, having inherited this characteristic from grapefruit. While they are well colored and very juicy, they have a peculiar, strong flavor somewhat reminiscent of the tangerine and disliked by some people and greatly favored by others. Because of lemon scab these varieties have been more or less dropped from commercial development and newer varieties such as the Orlando, Seminole and Mineola, which are resistant to scab, have been developed to take their place. These are being extensively planted at present as specialty fruits for the box trade and to some extent the Orlando is being planted as a possible early orange. Most of these varieties are attractive because of their high color and smooth skin and are excellent specialty fruits for dooryards or for the express box trade. Their commercial value for large scale production is not yet certain.

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[1] For more details on limes and lemons see: Limes and Lemons in Florida. State Dept. of Agr. Bul. No. 102, July, 1940.

[2] Swingle, Walter T., T. Ralph Robinson, and E. M. Savage. New Citrus Hybrids. U.S.D.A. Circular No. 181, August, 1931.

Kumquats. The kumquat does not belong to the genus *Citrus* but to the closely related genus *Fortunella*. There are several varieties of kumquats which are mainly used as ornamentals, although the fruit is used to some extent in trimming express boxes, and the large oval Nagami kumquat is shipped to processors for making marmalades and conserves. The Marumi is a small round fruit and is used as an ornamental.

Another fruit of somewhat similar characteristics used as an ornamental is included here since it is probably a natural hybrid between the kumquat and some variety of citrus, possibly a sour mandarin. This is the Calamondin, which is a small fruit shaped like a tangerine but with very acid pulp. The tree grows tall, is well-formed with very beautiful foliage, and bears a very heavy crop of yellow to orange fruit. It is used mainly as an ornamental, although the fruit is used as a substitute for limes and lemons as well as occasionally for making marmalade.

There are a great many other groups of citrus and miscellaneous varieties which might be mentioned but for a more complete listing of these the reader is referred to "The Cultivation of Citrus Fruits," by H. Harold Hume. Among those which might be mentioned are the citron of commerce, the Shaddocks or pummelos which are grown commercially in the Orient and which resemble grapefruit, the various limequats which are hybrids between limes and kumquats, and the numerous citranges which are hybrids between the so-called trifoliate orange (*Poncirus trifoliata*) and various sweet oranges. Many of these are interesting as trees for the dooryard but have no commercial value at the present time.

CITRUS PROPAGATION

The growing of citrus fruits in Florida began with seedling trees. As the industry developed the superiority of budded trees over the seedling trees became apparent and led to the abandonment of the seedling method of propagation. Fortunately, the propagation of citrus by budding and grafting is very easy and its practice has extended beyond the nurseryman to the grove owner himself. Today many citrus growers, even including those with only a few trees in their dooryards, have acquired the skill necessary for the budding of nursery stock and the topworking of older trees.

The discussion of nursery practice given herein is based on the best commercial practices of today, together with knowledge gained in experimental work. A number of procedures are listed that are not in general commercial use but which have a certain amount of interest to growers at large.

The Seedbed

The seedbed should be located on good soil that is well drained and capable of producing first-class growth of the seedlings. It should be provided with irrigation, preferably of the overhead type, and some nurserymen prefer to cover it with a lath shade, although this is not necessary and the majority of seedbeds are planted in the open. The lath shade has a tendency to increase the amount of seedling diseases and makes the seedbed difficult to handle from this standpoint but minimizes the moisture problem (See Figs. 7, 8 and 9). The location selected should be well protected from cold and the soil should be well drained as this will reduce the trouble from seedling diseases. A fertile soil is of course desirable but it is sometimes necessary to sacrifice soil quality somewhat for the sake of good cold protection and good drainage. It is also desirable to use new land whenever possible and not to plant a bed the second time without letting it "lay-out" for a while. The same rules apply to the selection of land for nursery rows.

A small amount of fertilizer is needed in making up the seedbed. This fertilizer should have a high percent-

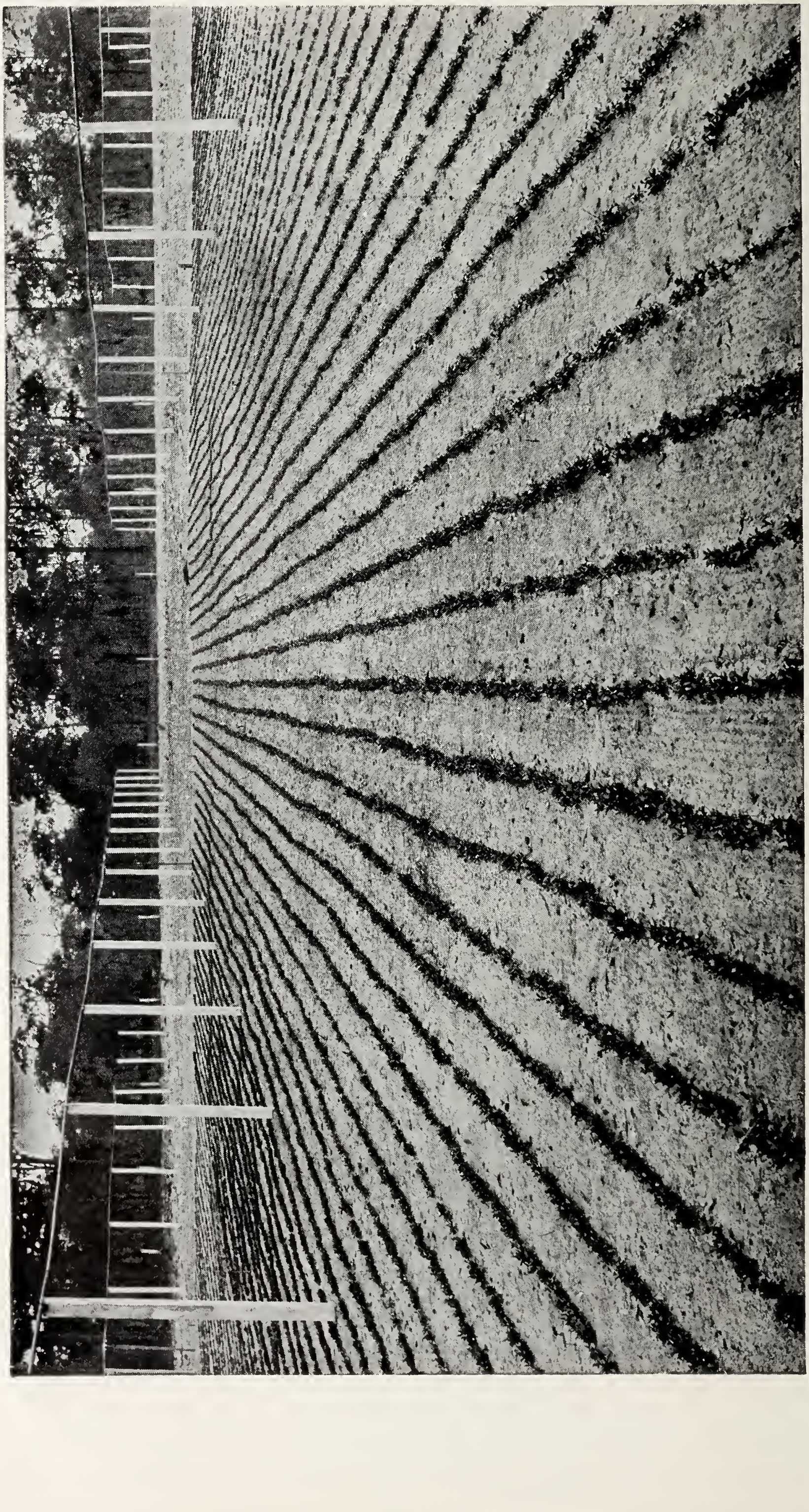

Fig. 7.—Nursery seedbed and very young seedlings. (Courtesy Glen St. Mary Nurseries.)

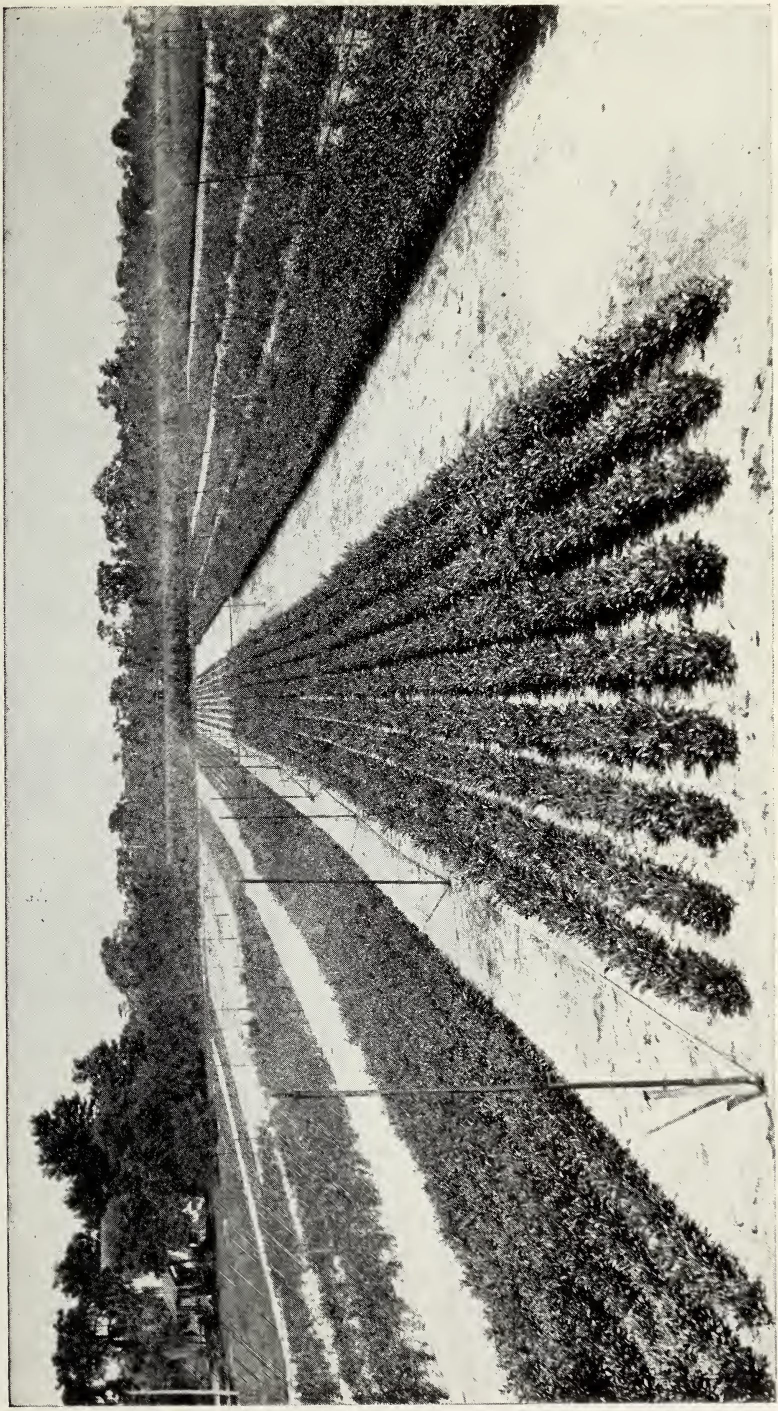

Fig. 8.—Nursery seedbed and seedlings almost ready to transplant to nursery row. (Courtesy Glen St. Mary Nurseries.)

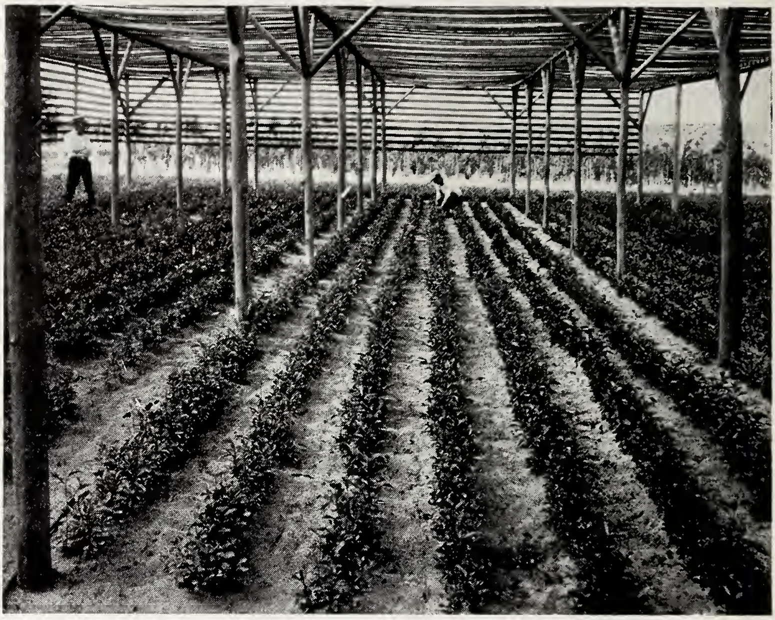

Fig. 9.—Citrus nursery seedbed under shade. (Courtesy Glen St. Mary Nurseries.)

age of nitrogen, largely derived from organic sources. The fertilizer should be added several weeks before the seeds are planted and worked thoroughly into the soil.

Where only a small seedbed is desired, the seeds are planted in rows wide enough for hand cultivation, but where a large number of seedlings are being grown the rows are laid out wide enough for horse cultivation. The seeds are planted thickly in the row and are covered with two to three inches of soil. Sour orange, sweet orange, grapefruit and rough lemon seeds are planted after the danger of frost is over, as very young seedlings are killed when frozen to the ground. *Poncirus trifoliata* seedlings are not completely killed by being frozen off, but sprout up from below ground; consequently, its seeds can be planted whenever they are ready.

The number of days required for germination of citrus seeds will depend upon the soil temperature and moisture and the condition of the seeds when planted. Experiments with fresh seeds have shown that the op-

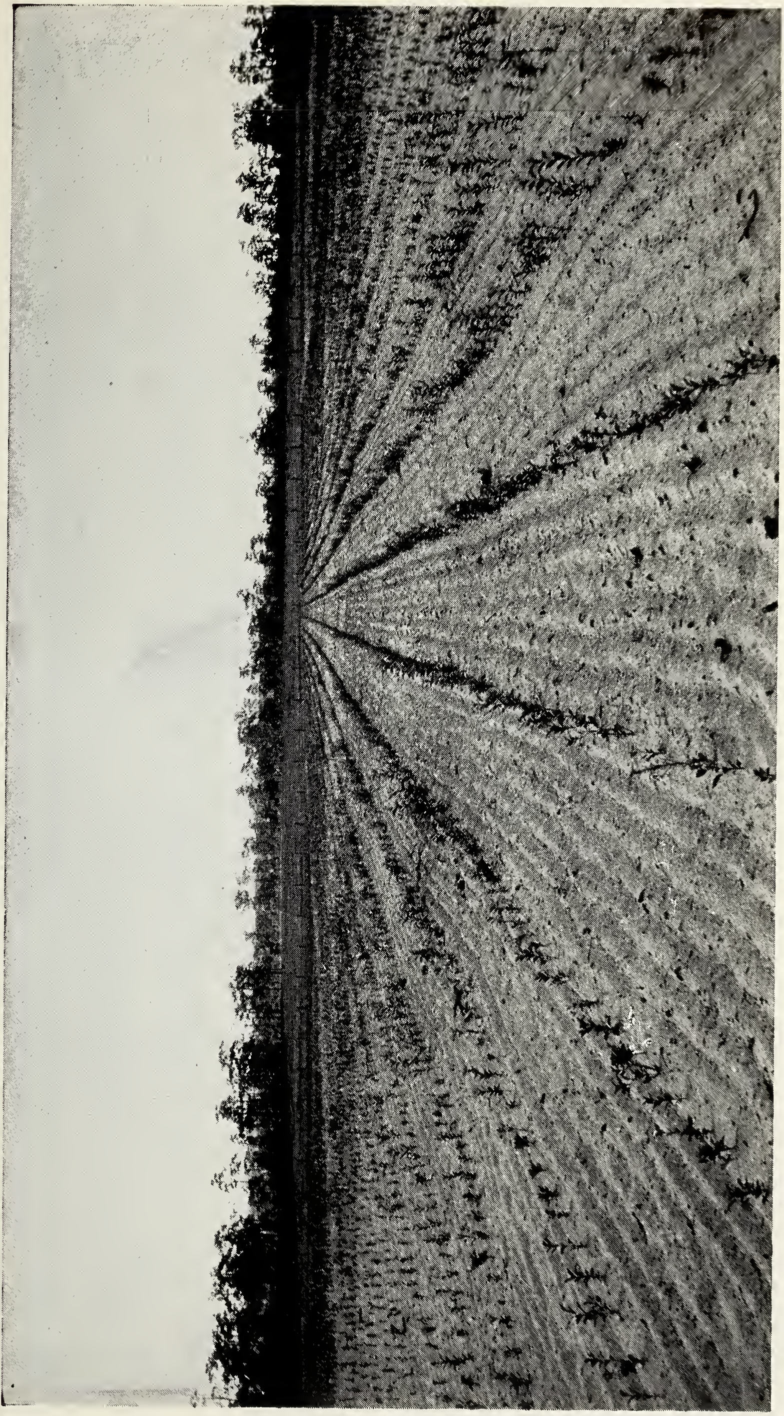

Fig. 10.—Citrus Seedlings in the nursery row ready to bud.

timum soil temperature for germination is about 90 degrees F. Near the optimum temperature, fresh seeds will sometimes germinate in two weeks but when the soil temperature is below 90 degrees F. a longer time is required for germination. In this connection, attention should be called to the fact that during the winter and spring the soil temperature is much lower than that indicated as the optimum and the time required for germination is correspondingly longer. The seedlings, however, are usually up in from 3 weeks to a month if the soil has been kept moist and the weather is not too cold.

After the seedlings have come up it is necessary to cultivate sufficiently to keep down weeds and to water enough to keep the plants growing well but not so much as to cause damping-off fungi to attack the seedlings. During the growing season 2 or 3 applications of fertilizer having a high nitrogen content should be made. Before the seedlings are removed from the seedbed, cultivation and fertilization should be stopped to allow the seedlings to harden up.

About 1 year from the September following the planting of the seed, making about 18 months in the seedbed, the seedlings are transplanted to the nursery row for further growth and budding. Seedlings are frequently transplanted after a much shorter period in the seedbed, but are harder to handle in the nursery row because of their small size. The seedlings can be removed by cutting the tap root 8 to 12 inches below the surface with a nursery spade, after which the seedlings can be easily lifted. The seedbed should be well watered just before the seedlings are removed. At least twice as many seedlings should be grown as it is intended to plant and only the best seedlings used.

In transplanting seedbed stock to the nursery row, the soil is usually opened with a spade. Care should be practiced to prevent the doubling up of roots, particularly the tap root, when planting. If necessary, prune

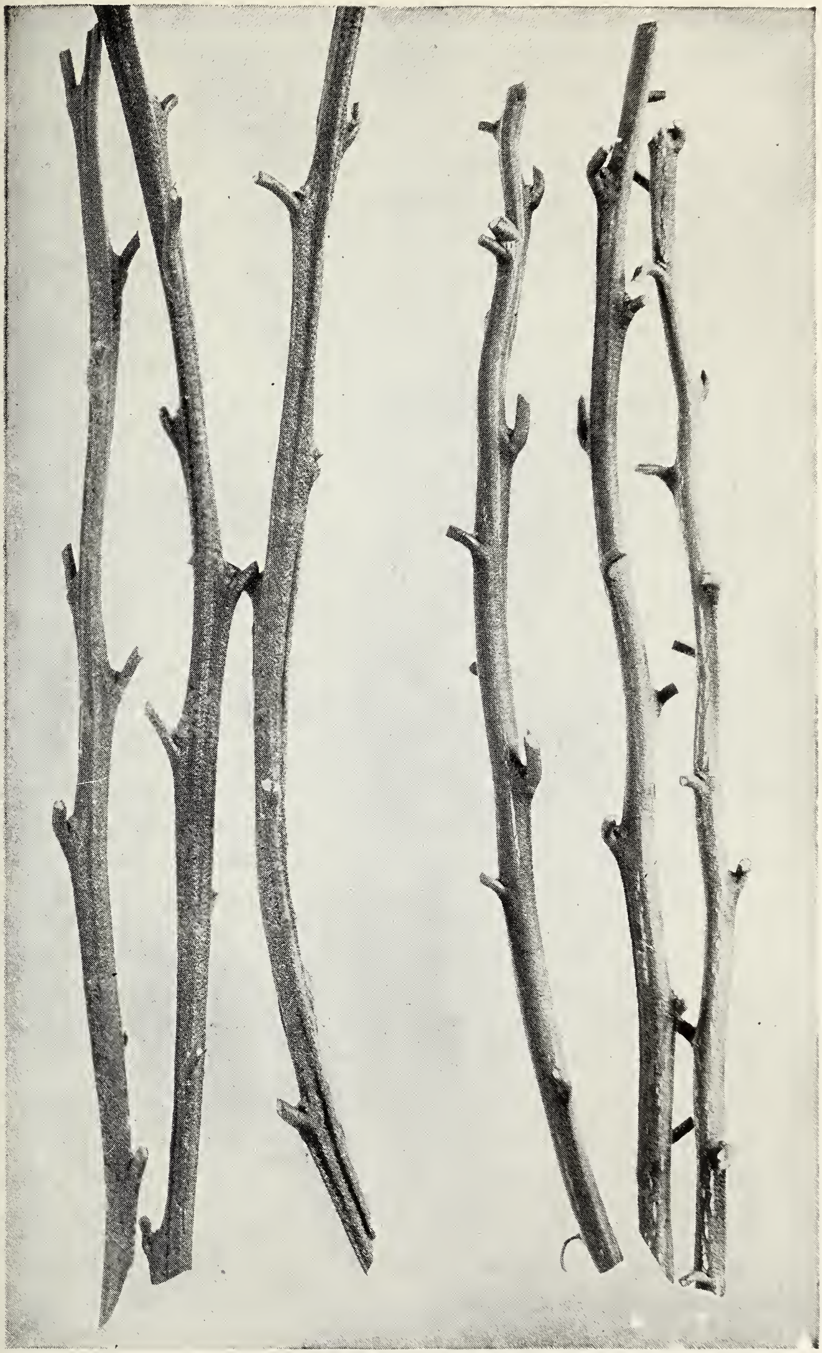

Fig. 11.—Citrus budwood. The wood on the left is too angular; that on the right is of better quality.

back the roots before attempting to plant. Watering at the time of planting is highly desirable if the soil is even slightly dry.

The nursery rows are usually three to four feet apart and the trees are planted about twelve inches apart in the row, the distance varying in different nurseries (see Fig. 10). Generally speaking, the rows should be wide enough to permit the use of a horse or mule in cultivating and the trees should be far enough apart in the row to permit the free use of a hoe between the trees. The trees are grown in the nursery row for about one year before being budded. Budding is usually done in the fall—September, October and November—but may be done in the spring or summer.

Budding Nursery Stock

The standard method of propagating citrus nursery stock is by budding. While the seedlings can be readily grafted by several different methods, these are never used in practice because budding is so much simpler, quicker and more economical of budwood than is any method of grafting. Citrus can be budded whenever the bark will "slip," that is, whenever it will separate readily from the wood. This condition exists during most of the spring, summer and fall, but in nursery practice it is customary to do most of the budding during the fall. Budding at this time is called dormant budding because the buds do not start into growth until the following spring. When the stock is large enough to bud in the fall a delay until spring will result in 3 to 4 weeks' loss of growing time in the budded tree.

Budding in citrus is accomplished by the insertion of a shield shaped bud into a "T" slot cut in the bark of the stock. The leg of the "T" is parallel with the axis of the stock and the top of the "T" across the stock at either the top or bottom, thus making either an erect or inverted "T" as desired. The buds are cut from wood about the size of a pencil or a little smaller, which has outgrown its angular condition and will usually be of the flush previous to the one occurring about the time the budding is done. In Fig. 11 are shown two types of budwood, namely, the angled wood which is considered unsuitable except for certain special types of budding, and the round wood which is desirable. The tree from which the budwood is selected should bear satisfactory crops of fruit true to the varietal type. In nursery practice, buds are commonly taken from blocks of nursery stock of the desired variety. When the block records are accurate and where the practice of frequently obtaining new budding material from bearing trees is followed, this practice is not as bad as it would at first appear. A certain number of off-type trees will appear but they may also appear in blocks budded from bearing trees. This practice is quite common and aside from other considerations has been followed because of the difficulty in obtaining large amounts of suitable budwood from bearing trees. If, as has happened in some cases, buds are obtained only from nursery trees and several generations of trees are produced entirely by transfer of buds from one block to another, it may easily happen that a considerable number of off-type trees may appear and if care is not continually practiced, some mixing of varieties may occur. If buds taken direct from parent trees are not obtainable in sufficient quantity, it is better to bud a small block of nursery trees each year from suitable bearing trees and to use buds from these for larger blocks the following year. The constant reference back to bearing trees in this way more nearly approximates the ideal system of obtaining all buds from bearing trees.

For the benefit of those just starting in the nursery business and for those who are raising trees for their own groves, it should be pointed out that there is considerable variation in citrus varieties in Florida. In selecting bearing trees as a source of budwood it is not sufficient to take any tree that has been casually identified as belonging to a variety. Budwood should be obtained from trees that have a record of good production of true-to-type fruit and the greatest care should be used in this selection. Trees that produce poor or freakish fruit usually will transmit these characteristics to trees budded from them. Research work has shown that psorosis is bud transmitted and is probably not transmitted by insects or in any other way. There are also other virus diseases which are also transmitted by buds, in fact, all of the known viruses of citrus are so transmitted. Many of them, however, are insect transmitted so that selection of buds will not entirely eliminate them. In order to be as free as possible of future trouble, however, all budwood should be taken from trees which show no indications of psorosis, either as gummy outbreaks on the limbs or trunk or leaf symptoms of the disease. In case of doubt, it is better to consult someone who is expert in identifying the psorosis disease by means of the leaf symptoms and have the leaves of the spring flush examined before taking any buds. It is well to remember at all times that the trees are not likely to be any better than the tree from which the budwood was obtained. A system of bud certification is now being put into operation by the State Plant Board to reduce the occurrence of psorosis and other bud-transmitted virus diseases.

For convenience in budding, the budwood is usually cut into pieces from 8 to 12 inches long, each piece carrying several buds. The budwood should be of good normal growth, well rounded and hardened sufficiently to handle well. As soon as the budwood is cut from the tree it should be defoliated by cutting the leaves off with a knife or pruning shears, leaving a piece of each petiole attached to the wood. When it is necessary to store the budwood until the stock is ready for budding, the sticks can be packed in cypress sawdust or in damp sphagnum moss and held in a cool place. If stored in sawdust it will be necessary to repack occasionally.

A knife having a blade of the very finest steel, with rounded end, is necessary. The blade should be made of steel comparable in quality to razor steel and carefully ground and honed to a smooth, thin edge. Many very careful workers prefer to finish sharpening the knife with a strop similar to a razor strop. Unless the knife is of very fine quality and very carefully sharpened, it is impossible to make smooth cuts and to open up the bark without leaving loose shreds which interfere with the insertion of the bud. Standard budding knives are commonly made with a bone handle with a flat, wedged end for opening up the bark where necessary, but the handle is seldom used by specialists in budding.

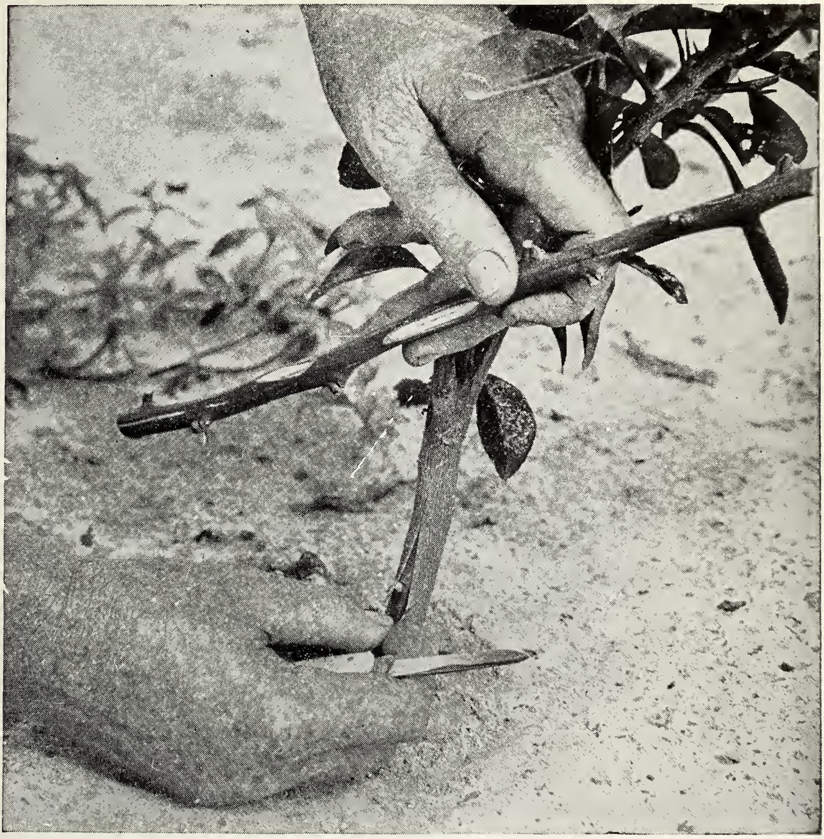

Fig. 12.—One method of insertion.

Budding tape for wrapping the buds is made from thin bleached muslin put up in rolls 6 to 8 inches long, and 1 to 2 inches in diameter. These are impregnated with a grafting wax that will not harden. Of a large number of formulae for the wax, the one below, taken from Hume's "Cultivation of Citrus Fruits," is considered very satisfactory for use under Florida conditions:

Rosin	1 lb.
Beeswax	4 lbs.
Raw pine gum	3 tbsps.

The grafting wax is heated over the fire until melted, a large iron kettle generally being used, and the rolls are immersed in it until thoroughly impregnated. The wax must not be too hot during the procedure and a good practice is to bring the wax to a boil so it can be skimmed, then allow it to cool somewhat before immersing the rolls of cloth. Plenty of time should be allowed so as to obtain thorough penetration and the procedure can be helped by moving the rolls around in the melted wax. If the rolls of cloth are too large, the wax will not penetrate and the diameter, therefore, should be kept below two inches. To secure better penetration, many workers tear the muslin in 36-inch squares and fold these into smaller squares for ease in handling prior to impregnation. These are immersed in the melted wax and unfolded with sticks to make sure of even penetration. The sheets are then stretched on bamboo poles to drain and dry. After the cloth is cool it can be torn off in strips the proper width for use, as needed.

Any number of variations of this procedure have been suggested or adopted by various budders, according to personal preferences. A good grade of muslin, put up in proper rolls and thoroughly impregnated with wax, can be torn to any width desired, whereas tapes and other materials made a definite width beforehand lack the flexibility in handling afforded by the above method of preparation. The cloth should be capable of withstanding considerable pull and the wax should be one that will retain a certain softness and not harden on exposure.

Budding in the nursery usually is carried out on seedlings from the size of a pencil up to an inch in diameter, but trees ½-inch to ¾-inch caliper are most desirable; trees that are too small should be discarded. The trunk of the seedling is pruned clean of thorns and limbs, ahead of the budder so as to save time, and the soil is

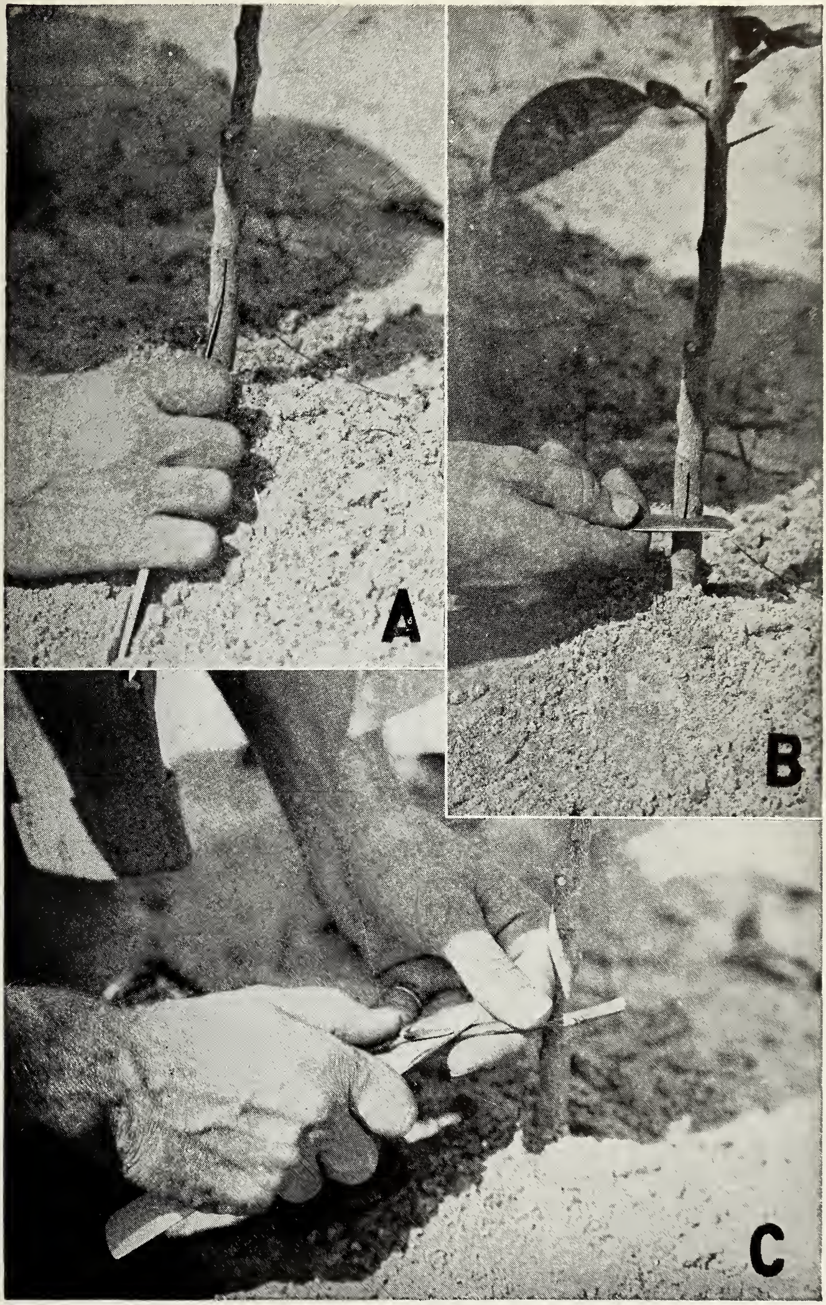

Fig. 13.—Initial steps in the budding process. A, making the vertical cut; the cutting stroke is usually downward but may be made upward if desired. B, making the cross cut at the bottom of the vertical slit; note tilt of knife blade. C, cutting the bud shield from the bud stock. (Cf. Fig. 14.)

scraped away if the bud is to be placed close to the soil. With the knife grasped in the right hand and the edge of the blade downward, a downward cut is made about an inch and a half long (Fig. 13-A). This is a vertical cut through the bark but no farther into the wood than is necessary to be certain that the bark has been completely cut. If desired, this cut can be made upward instead of downward. The knife is now used to make a cross cut at the bottom of the vertical cut, thus making an inverted "T" (Fig. 13-B). In making this cut, the back of the knife blade is tilted slightly downward so that the cut is a little upward as well as across the stock. At the finish of the cut, the knife blade is tilted slightly upward and given a slight twist to open the bark at the junction of the horizontal and vertical cuts.

The bud is now cut from a stick of budwood held as in Fig. 13-C, the basal end away from the operator. The cut is toward the operator and is made as nearly as possible parallel with the axis of the budwood, and with a slight rotating motion. The knife is held with the blade almost parallel to the axis of the budwood and the thumb of the knife hand used to steady the budwood in making the cut. This will give a shield-shaped piece of bark and wood about ¾ to 1 inch long with a flat, smooth cut surface. *The bud should not be scooped out,* as this will cause too much wood to be taken with the bud. As the cut is finished, the thumb retains the bud on the blade of the budding knife and at the lower end of the shield. Using this method of holding the bud, with thumb and knife blade, the upper end of the bud is inserted in the stock as in Fig. 14-D, showing another method of insertion. The bud shield when inserted is entirely beneath the bark and should be pushed far up into the vertical cut (Figs. 14-E and -F). The bud should be handled very carefully so as not to injure it during the procedure; inexperienced operators may tear up the edge of the shield in the process of inserting it under the bark and sometimes will use the point of the knife to push it into place and badly injure the bud in this way. Considerable practice

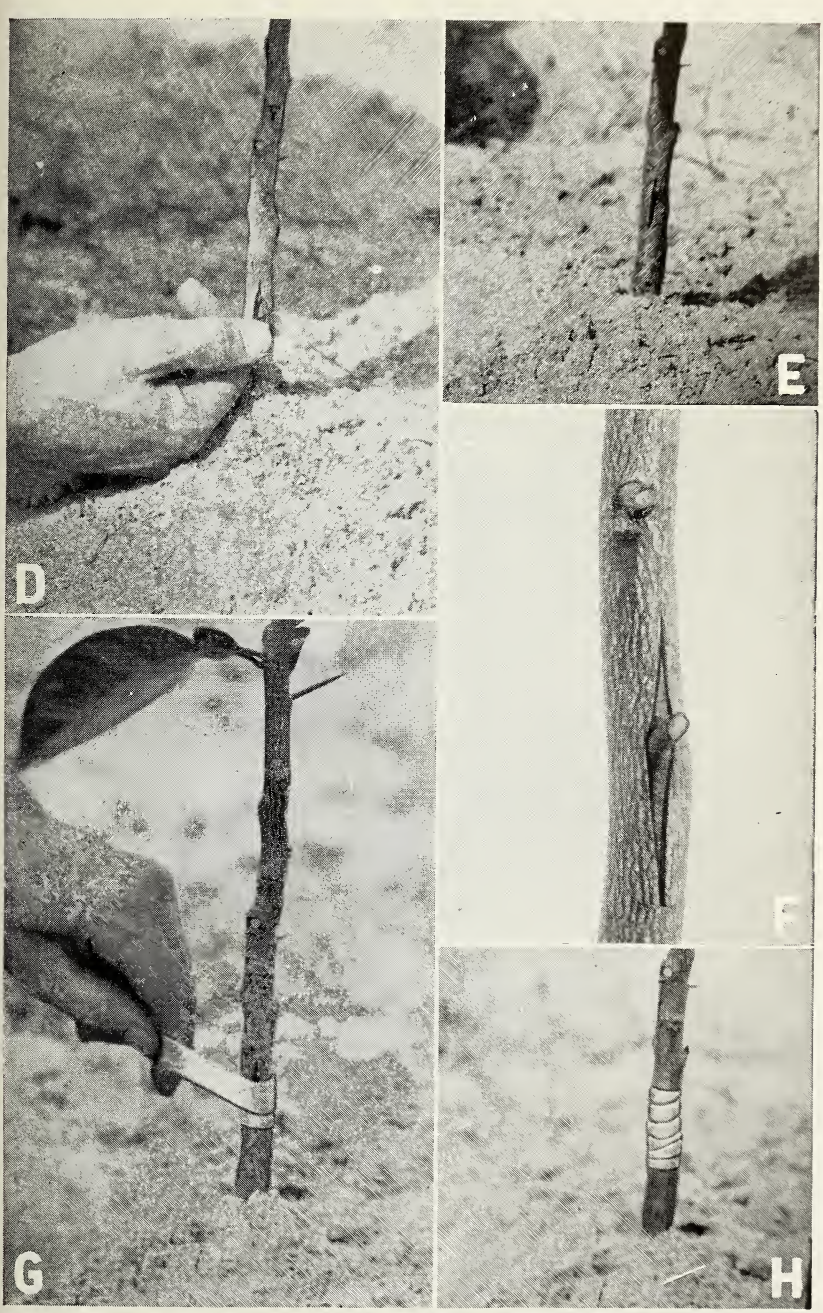

Fig. 14.—The final steps in the budding process. D, inserting bud shield in stock; bud is being held on knife blade. E, bud shield in place in stock; note that it is entirely within the flaps of bark. F, a closer view of the shield bud in place. G, taping the bud; taping is started at the bottom in inverted "T" budding and at the top in erect "T" budding. H, taping finished; end of tape is brought back on tape wraps so that it will stick.

is necessary to carry out the procedure rapidly and smoothly so as to insert the bud into place with the edges of the shield smooth and untorn and the bud uninjured, but unless this is done the bud has a poor chance of "taking." The inexperienced worker in watching the experienced budder frequently gets the impression that the work can be rapidly and carelessly done, whereas the speed really comes from a great deal of practice so that all operations are done accurately as well as rapidly.

Taping is started below the bud and the tape wrapped firmly but not too tightly around the trunk of the seedling up to above the top of the vertical cut (Figs. 14-G and -H). As the wrapping is finished the end of the tape should be brought back onto the cloth, as this will make it adhere more firmly. For wrapping buds it is usually found desirable to tear the cloth in about ¾-inch strips, but the size of stock and other conditions will influence this considerably. It is important that the wrapping be sufficiently tight to prevent the entrance of water into the wound and to hold the bud and the stock closely together so that callousing will start and a union be formed. After 10 days to 2 weeks the buds can be examined and if still green and showing callous formation indicating that they have "taken," the tape can be removed.

The type of budding here illustrated is described as inverted "T" incision. In California the erect "T" is used, that is, the cross cut is made at the top of the vertical cut instead of at the bottom as in the Florida method. It is claimed that the inverted "T" method keeps out moisture better and allows the bud to "drain," although the real reason is probably to be found in custom, as either method will work satisfactorily. When the erect "T" is used, the wrapping is started at the top, that is, at the point of intersection of the two cuts.

The distance of the bud from the ground must be determined by conditions under which the trees are to be used. Sweet orange scions on sour orange stock can be affected with foot rot if water or mud stands above the bud union, just as readily as seedling sweet oranges

FLORIDA'S CLIMATE AND FLORIDA'S CITRUS FRUIT MAKE DELIGHTFUL LIVING CONDITIONS

can be attacked. Where the budded trees are to be planted in moist locations, the buds should be high above the ground but when they are to be planted on drier lands the bud may be within 2 or 3 inches of the ground to facilitate protection against cold by banking. Under Florida conditions, the buds usually are placed as close to the soil as it is convenient to work, that is, 2 or 3 inches.

When the bud starts to grow the seedling top is cut off smoothly just above the bud, thus throwing the growth to the bud. Dormant budded nursery trees are cut back in January or February before spring growth starts. When the seedling is very large at time of budding the top is sometimes "lopped" when the bud starts by cutting it partially through. This helps to start the bud and at the same time leaves some top to support the roots (Fig. 15). Lopping reduces the chances of the bud being flooded or drowned by excessive sap flow which may occur if a vigorously growing top is entirely removed. The cut should be on the same side as the bud. After the bud shoot has grown 6 to 12 inches high, the old seedling top is entirely removed with a pair of sharp clippers, making the cut close to the bud. Lopping is seldom practiced in nurseries where normal seedlings are being budded but is sometimes used where seedlings that have remained too long in the nursery row are being worked.

As soon as the buds start to grow it will be necessary to put a stake at each tree and to tie the shoot to the stake from time to time with raffia or coarse string (see Fig. 16). The stakes may be of good heart pine or cypress ¾ to 1 inch square and 4 feet long, or they may be of heavy galvanized wire. If old stakes are used they should be free of termite and ant colonies. Many nurserymen using wooden stakes make it a practice to place the stake on the north side of the scion to give a little protection from the north winds. The best practice is to place the stake in the angle formed by the scion and the stock. The stake is close to the scion, making training easy, and out of the way of the cultivator. If the stake is placed on the opposite side of the stock from

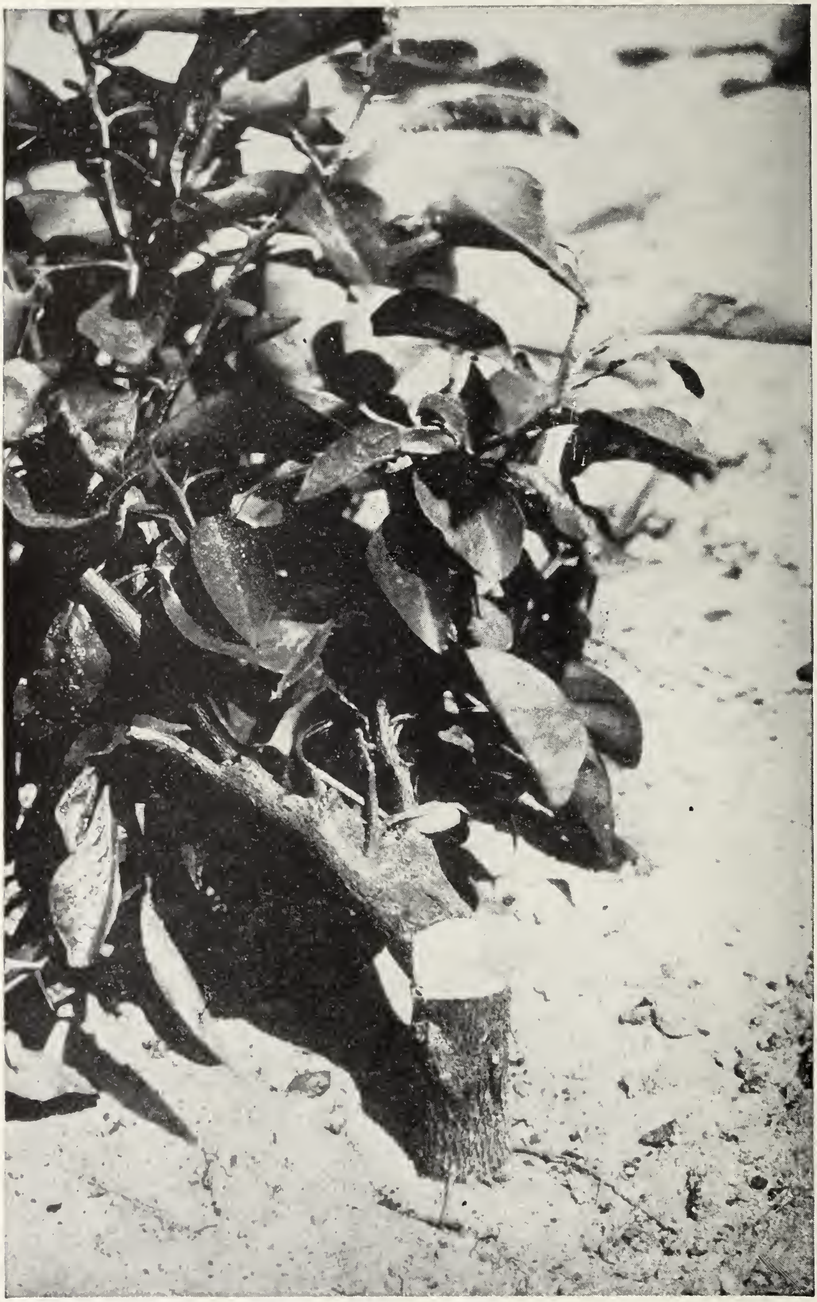

Fig. 15.—"Lopped" seedling, showing bud that has just "taken".

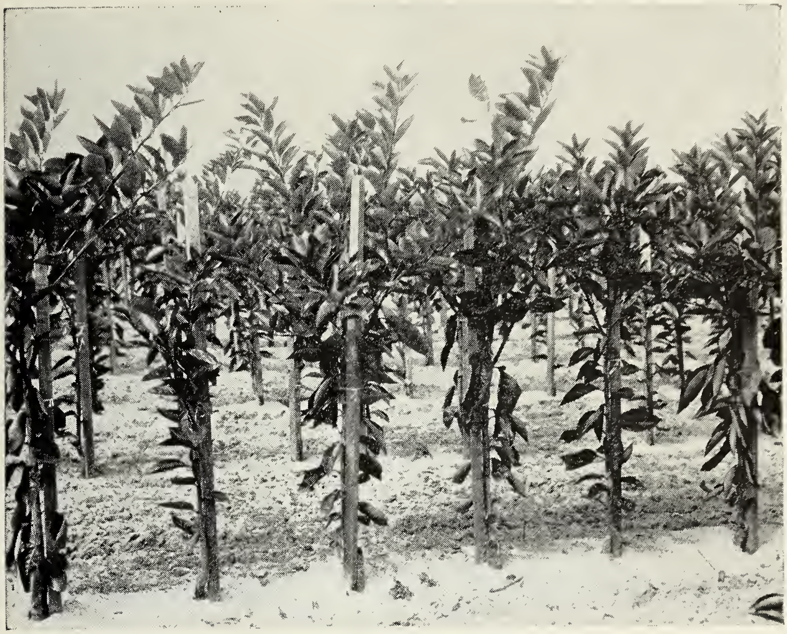

Fig. 16.—Nursery trees staked and tied—wooden stakes.

the bud, the scion will be bent in training. When the shoot is from 1 to 3 feet high, it is usually topped, thus starting the formation of a framework for the tree. The height for topping is determined by the operator to produce the type of tree desired.

A large number of other methods of budding can be used but are not ordinarily necessary in citrus. Some of these, such as ring or patch budding, are particularly adapted to some trees that are budded with considerable difficulty, usually due to a thick and brittle bark, and which will not respond readily to shield budding, but these methods are not used in citrus. Some variations of the shield bud are used in working stocks that are too hard or in utilizing budwood that is too angled to permit of the cutting of satisfactory shields of the usual type. Two of these methods are illustrated in Fig. 18. These two pictures represent types of what is called side budding, this method being sometimes used on stocks that are too hard for the usual method of shield bud-

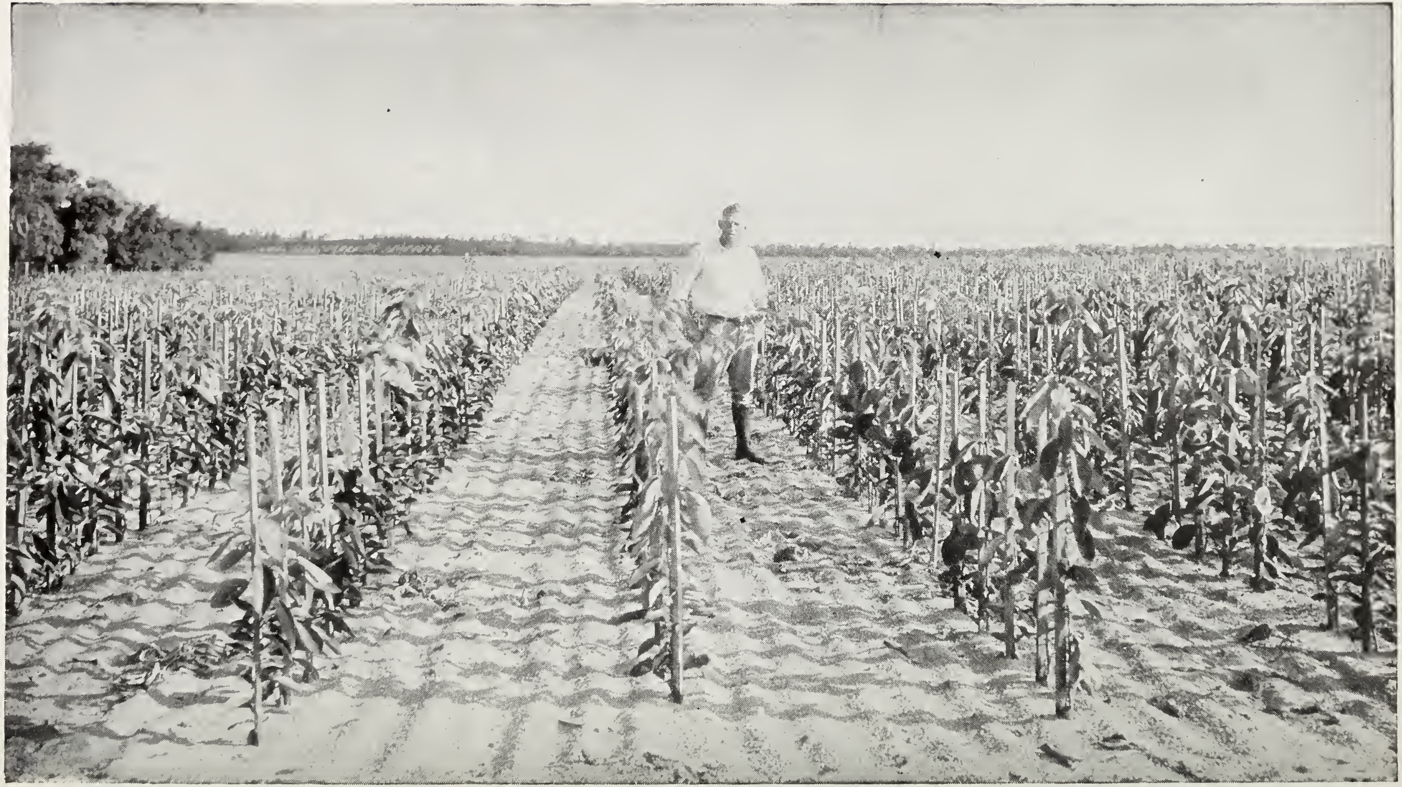

Fig. 17.—Field of budded trees. (Courtesy Glen St. Mary Nurseries.)

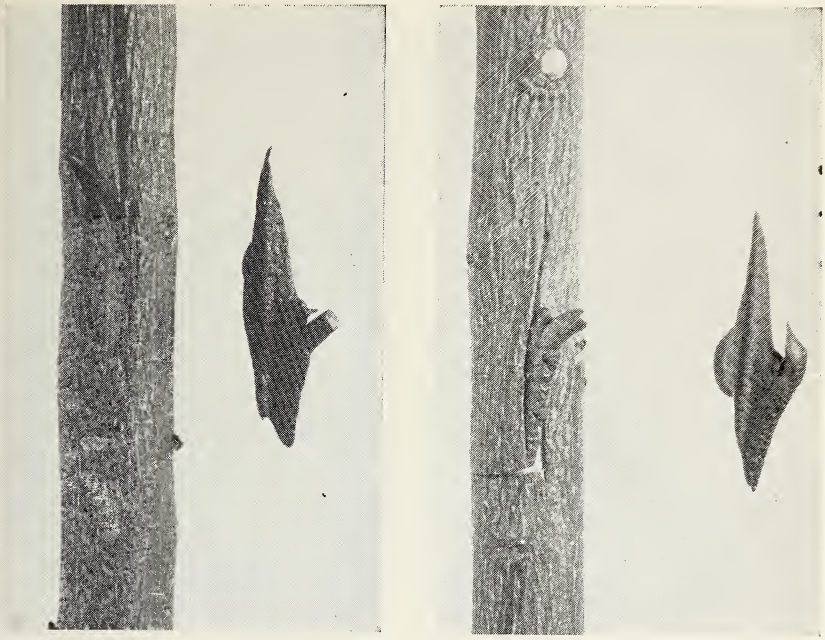

Fig. 18.—Side budding with curved incision on left and angled incision on right. Either shield can be cut from angular budwood to better advantage than can the ordinary shield.

ding. Note in particular the shape of the bud shield with the bud eye on the side of the shield instead of in the center. This type of shield can be readily cut from very angular budwood. Except for the shape of the bud shield and the method of making the incision in the stock the procedure to be followed is the same as that followed in "T" or inverted "T" budding. Occasionally with either of these types of side budding a small sprig of budwood with 3 to 5 buds on it is substituted for a shield bud. This type of procedure is frequently used in experimental work where the wood available is too small for shields to be cut from it.

In budding large blocks of nursery stock the pruner usually cleans off the leaves, thorns, and limbs where the bud is to be inserted, ahead of the budder, and the pruner or another helper will scrape away the soil, if this is necessary. The budder has a tier working with him who wraps the buds. Under such conditions a good budder may put in as high as 1,500 or more buds a day,

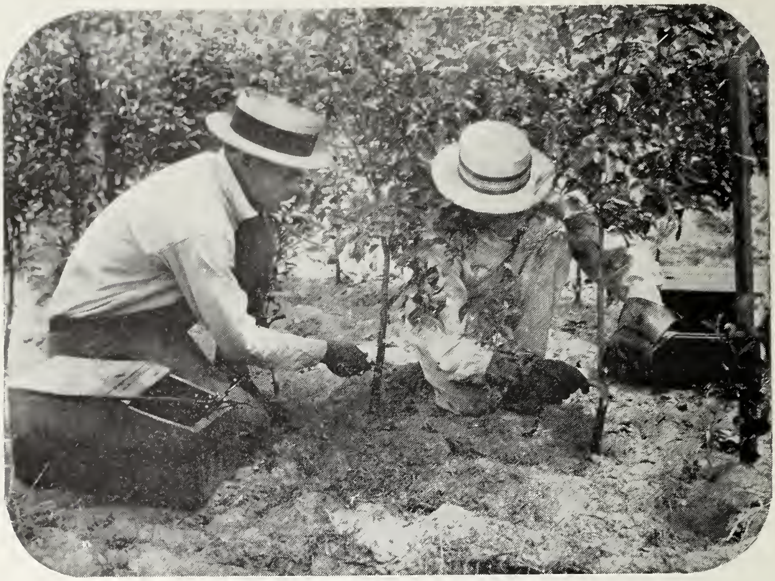

Fig. 19.—Budding citrus trees.

his efforts being entirely devoted to the highly skilled operation of cutting and inserting the buds. In nursery practice the tier always uses budding tape but where small amounts of work are being done other methods of holding the bud in place are sometimes used. The bud may be tied in with raffia or string and the whole wound painted over with a mixture of melted paraffin and carnauba wax. In case this method is used, a special lantern containing an alcohol lamp and a cup in which the wax is melted should be obtained. Special wide rubber bands are also used occasionally for tying.

In dormant budding it is sometimes necessary to protect the bud from cold. This can be done by banking the trees with soil after the wraps are removed, by plowing a furrow to each side of the row. This soil is removed after danger of frost is past.

Handling Budded Trees

Cultivation and fertilization of budded trees should be such as to promote thrifty growth. The nursery rows are cultivated frequently to keep down weeds and grass, a horse-drawn cultivator being used for cultivating the middles and the rows being hoed out by hand. In the fall, cultivation is reduced so as to harden the trees before frost. The amount and type of fertilization will depend greatly on the type of soil. A fertilizer analyzing 4 to 5 percent nitrogen, 6 to 8 percent phosphoric acid and 4 to 6 percent potash is suitable. Three applications of fertilizer per season should be made, the first just prior to the start of growth in the spring, the second in June and the third in late August or early September. The amounts will vary from 500 to 1,500 pounds per acre per application, depending on the fertility of the soil. The applications may be made broadcast and worked in with the cultivator but usually the first is applied by "barring off" the rows (plowing a furrow away from each side of the row with a small turning plow) and placing the fertilizer in the furrow and covering it by plowing the soil back into the furrow. Too much fertilization and cultivation should be avoided as an excess tends to produce too rank and soft a growth.

As pointed out previously, the scion must be tied to the stake from time to time so that it will have a straight trunk. The height at which it is to be topped to form the framework of the tree will depend on the type of tree desired. Of late years the tendency has been to the growing of low-headed trees and the scions are usually topped at about 18 to 24 inches. In addition to the work of training the scion, sprouts must be removed from both stock and scion occasionally. When the tree has developed a strong trunk, the stake is removed so that it will not be in the way when the trees are dug.

Budded trees are allowed to grow at least one year in the nursery row before being placed in the grove. The grading of nursery stock after off-type and freak trees are eliminated is usually done by caliper (i.e., the diameter of the trunk 2 inches above the union is measured) and by the age of the trees from budding. Trees for planting should preferably caliper ⅝-inch or over after 1 year from budding. Two-year trees should be larger. Trees that failed to make satisfactory growth the first year are commonly left in the nursery for another year's growth. Some nurserymen prefer to cut back such trees to the bud and make an entirely new top the second year, but trees that are badly stunted should be discarded.

Digging Nursery Trees

Nursery trees are dug as ordered and the selection of the trees is based on the size desired to fill the order. In digging nursery trees the foreman of the crew usually selects the trees to be dug and prunes them back with longhandled shears to a framework or a stub, according to instructions (Fig. 20 and 21); the remaining leaves and twigs are cut off with a knife or pruning shears and the lateral roots are cut off in a circle around the tree by means of long-bladed nursery spades (Fig. 21-D). A hole is then dug on one side of the tree so that the spade can be driven under the tree at the proper depth to cut the taproot (Fig. 22-E). The tree is then "lifted" with the help of the spade and the roots are immediately covered to prevent drying out (Fig. 22-G). The trees may be loosened as in Fig. 22-F, but left with the roots still in the soil until the truck or wagon comes, and then the trees can be quickly lifted and placed under cover. It is very important that the roots should not be allowed to dry out before planting. This applies not only to the process of digging but also to the hauling and handling of trees, particularly when they are to be removed by truck or wagon directly to the field where they are to be planted.

The practice of handling citrus nursery stock "bare rooted" is universal in Florida. In California, however, the trees are "balled," that is, dug with a ball of earth containing the roots and this is wrapped with burlap. Difficulties attached to handling trees in this way in the light of Florida soils are obvious. Moreover, the trees grow so readily when transplanted under Florida conditions that this procedure is found to be unnecessary.

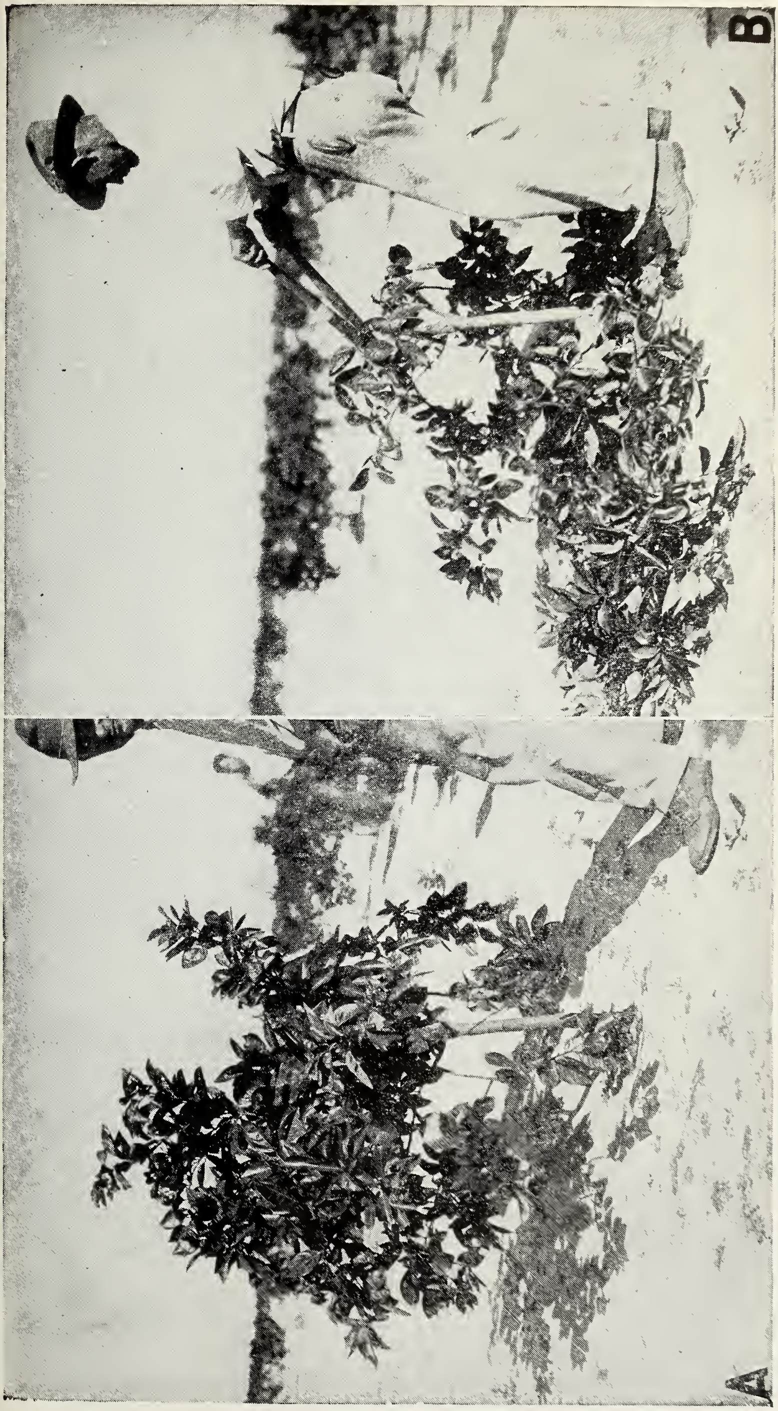

Fig. 20.—Digging nursery trees. A, tree ready for digging. B, pruning back with lopping shears preliminary to digging. (Cf. Figs. 21 and 22.)

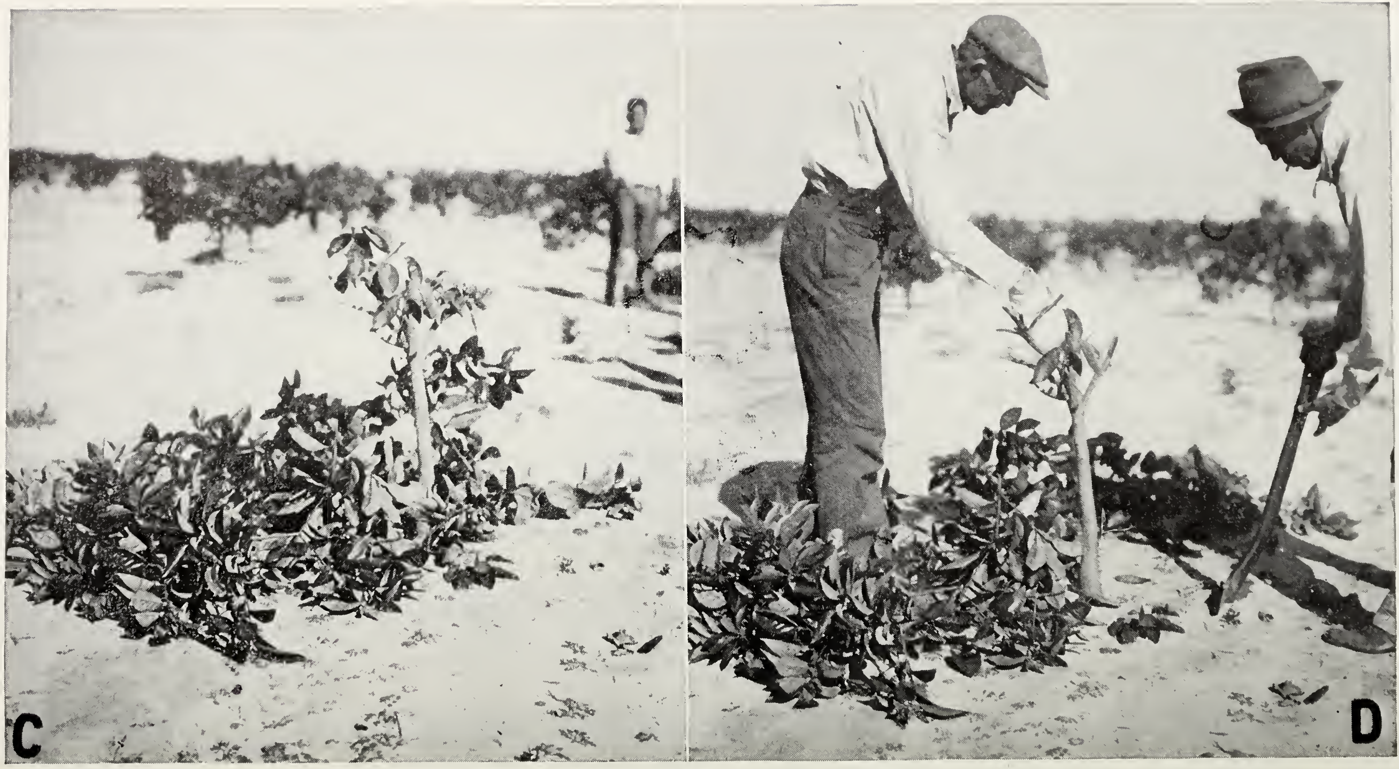

Fig. 21.—Digging nursery trees. C, tree pruned back for digging. D, digging the tree. The man on the right is cutting the lateral roots with a spade; the one on the left is cleaning off the leaves and twigs remaining after pruning. (Cf. Figs. 20 and 22.)

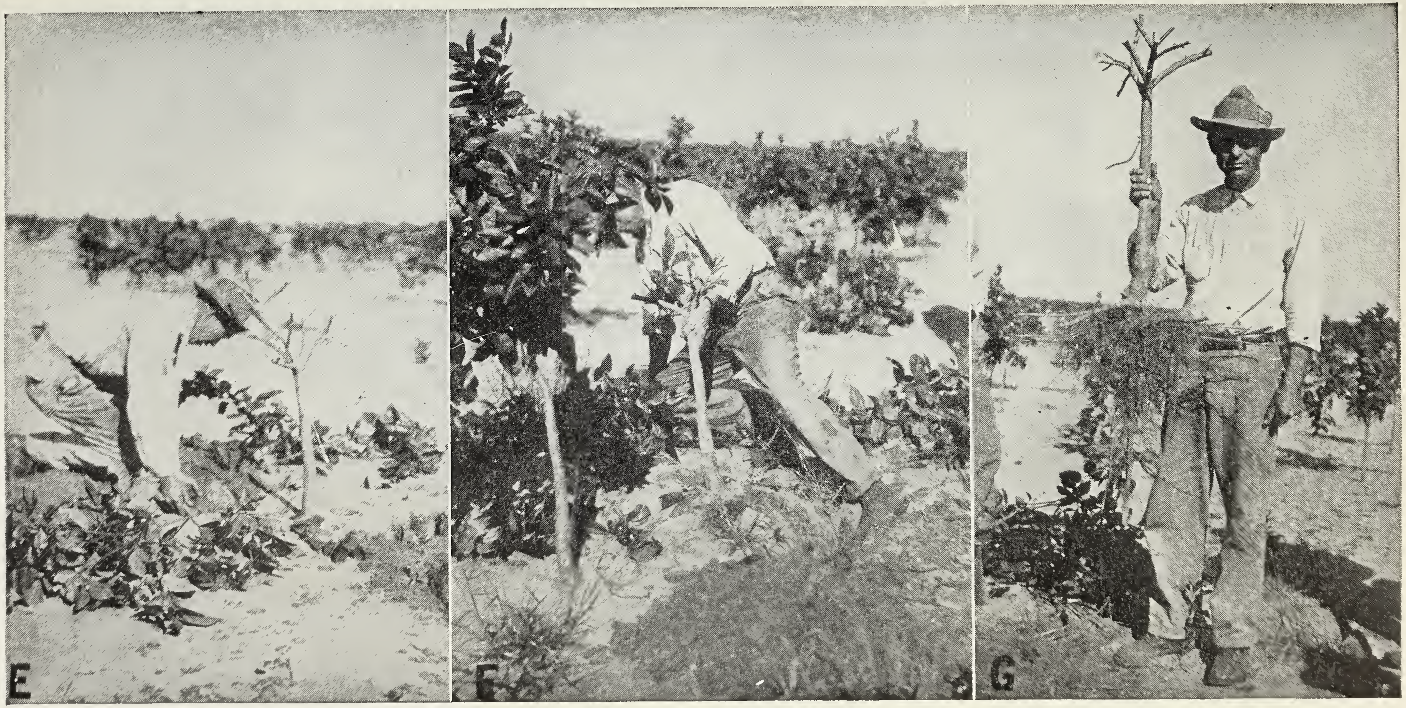

Fig. 22.—Digging nursery trees. E, cutting taproot of tree with a spade; note depth to which spade is thrust into soil. F, "lifting" a nursery tree; the worker's right hand holds the handle of the spade and with his hand and knee he is using the spade to help pry the tree up. G, the nursery tree lifted free of the soil; note the fine root system. (Cf. Figs. 20 and 21.)

Packing Nursery Stock for Shipment

Nursery trees are packed in various ways for shipment by freight, express or mail. A larger portion of the trees now move by truck directly to the grove site and for short hauls are commonly dug in the morning and planted in the afternoon. If the trees are wet down as they are loaded onto the truck and covered with wet canvas or burlap cover, they can be handled nicely for short hauls but for longer hauls it is desirable to pack the roots in moist sawdust or other materials and also to cover with a canvas to protect the top from drying winds. All methods of long distance shipment make use of some sort of protection for the roots—such as moist, sphagnum moss or "shingletoe" (sawdust from cypress shingle mills). In Fig. 23-A is shown a standard crate for the shipment of nursery trees. As shown in the picture, the crate is lying on its side and it is placed in this position while the trees are being packed in it. The 2-inch by 2-inch framing piece for the open side is removed and the box lined with paper before the packing starts. A layer of moss or shingletoe is placed for the roots and excelsior is used at the top of the box to protect the trunks against rubbing and to keep the packing for the roots in place. The trees are packed in tightly with alternate layers of packing material and finally covered with a layer of packing material and paper. The framing piece is then nailed back in place and a piece of 1-inch by 3-inch placed across the center of the open side and nailed to the sides to help hold the trees in place. The side boards are then nailed on and the box stood on end ready for receiving the burlap covering to protect the tops of the trees (Fig. 23-B). The tops of the trees are now covered with burlap which is attached to the crate by means of lath strips nailed to the top frame and securely sewed (Fig. 23-C). The crates shown are usually 30 inches high but the side dimensions may vary from 12 inches by 12 inches to much larger.

Smaller quantities of trees may be shipped in bales and 3 types of bales are shown in Fig. 23-D. These vary from a paper covered bale for mail order shipments

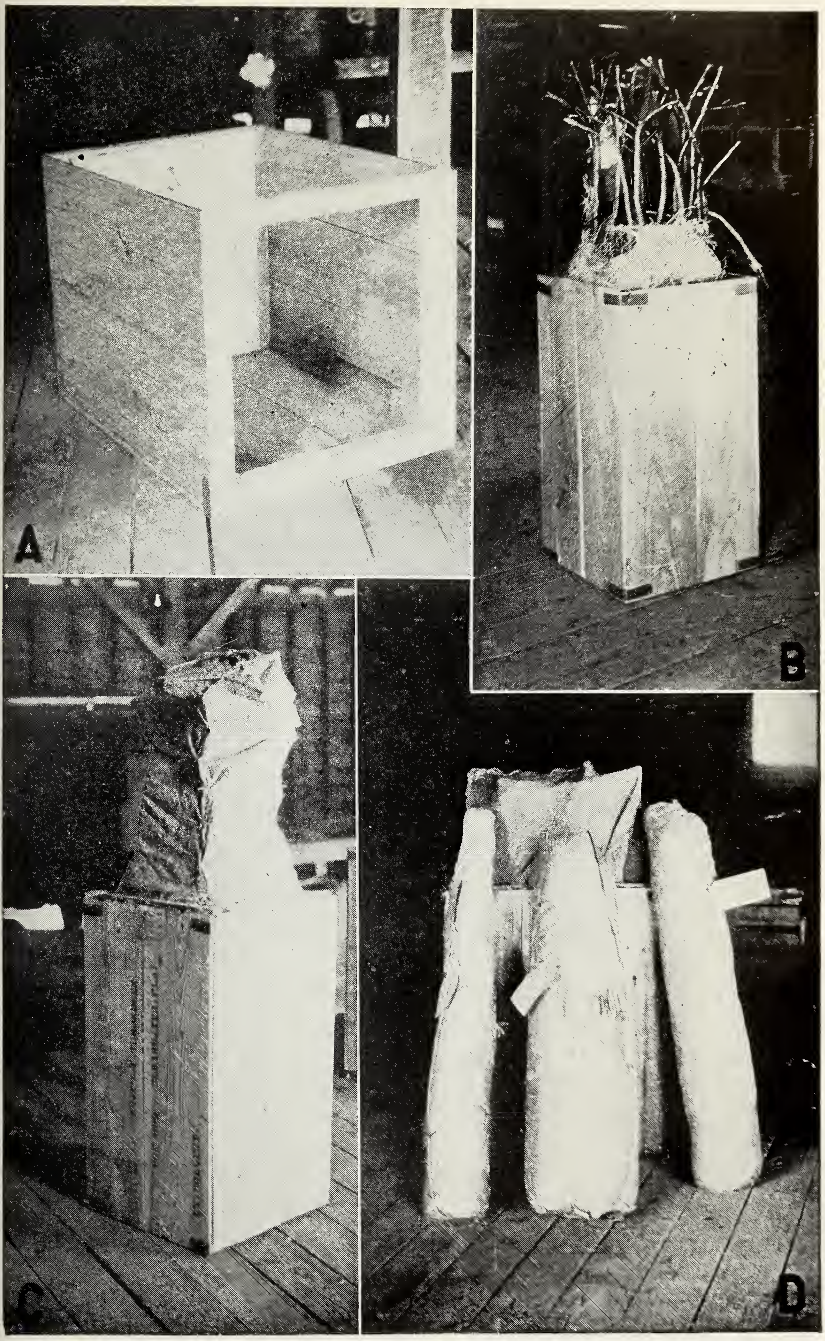

Fig. 23.—Shipping nursery stock. A, shipping crate, with end and one side (up) left open to facilitate packing. B, nursery stock crated and ready for burlap covering over the tops. C, crated for shipment. D, four types of packages for shipping citrus nursery stock. In the background the crate, on the left the paper-wrapped parcel for mail shipment, center corrugated paper and paper, and right burlap covering for express shipment.

to coverings of corrugated paper and wrapping paper or burlap for express shipments. In all cases the trees are packed in the proper packing material in much the same manner as described for the crates. Regardless of the type of package the packing must be done carefully to avoid drying out of the roots while in transit. For local shipments, shingletoe is commonly used around the roots but trees to be shipped to distant points are usually packed in sphagnum moss.

Top-Working

It is often desirable or necessary to top-work grove trees because of cold damage or when it is desired to substitute a new variety for an undesirable one. Top-working large trees, while tedious, takes advantage of the root system already present and brings a tree into production more quickly than can be done by planting young trees. Frequently it is desired to work over trees in yards so as to give additional varieties for home use and this is sometimes done by grafting or budding more than one variety on the same tree. The common methods for the top-working of trees are: Budding sprouts or shoots resulting from cutting back; budding old branches and then cutting them back; bark grafting or cleft grafting. The method used almost exclusively in this state is the budding of new shoots, some of the work being done on the shoots produced when trees are "hat-racked" and some on sprouts from the rootstock produced when trees are cut off at the bud union.

The budding of rootstock sprouts will be necessary when budded trees are killed to the bud by cold and the rebuilding of the orchard depends on the rootstock sending up sprouts which can be budded. In top-working relatively young trees this procedure is often more convenient and efficient than reworking the tops since there are no trunks and limbs left to produce sprouts of the original variety and relatively little time is lost. Moreover, in the case of tangerines which have brittle wood and a tendency to split in the limb crotches and Temple oranges which are dwarf in habit and also have brittle wood, the use of top-working on a framework is of doubtful value, both due to the effect of the old trunk on the new top and also due to the danger of breaking up the framework after a heavy top of grapefruit or orange is developed on it. Even old tangerine or Temple trees are commonly worked over to other varieties by cutting back to the bud union.

The procedure for working over young trees (6 years old or less) by this method, is to cut the trees off smoothly at or just below the bud union. It is usually desirable to start the cut on the side toward which it is desired to have the tree fall, cutting about a fourth to a third through and then finishing off with a cut from the other side so as to avoid excessive splitting of the stump. The stump is then dressed to a smooth surface and it is desirable to cover it with a good wound dressing. The sprouts that come up are thinned to a suitable number arising close to the cut area. On a very small tree one sprout can be left, but on stumps more than 2 inches in diameter leave 2 or more, according to the size of the stump. Enough sprouts should be left so that the stump will ultimately heal over and several sprouts also tend to grow together at the base and support each other. After the sprouts have hardened up they can be budded, using the procedure for nursery stock, but the work of budding should not be done too soon. After the buds have started, the shoots will have to be staked and trained. A nice piece of work of this type can be seen in Fig. 24.

Frequently it is desirable to work large tangerines in this way on account of the possible danger of splitting of the framework later. In such cases the shock to the root system when a large top is suddenly removed is extremely severe and may result in considerable damage. A better, but slightly more laborious, system is to cut the stump about ⅔ through and tip the tree over, leaving it attached to the stump (Fig. 25). The top may be held in place by fastening it to a large stake and this will prevent the top from being rolled around by heavy winds. The sprouts that come up on the cut side are properly thinned and budded in the usual way and after they are firmly established the cut is finished and the top removed. After this is done, another sprout or two may be worked at the point where the final cut was made in order to round up the new top and to help the process

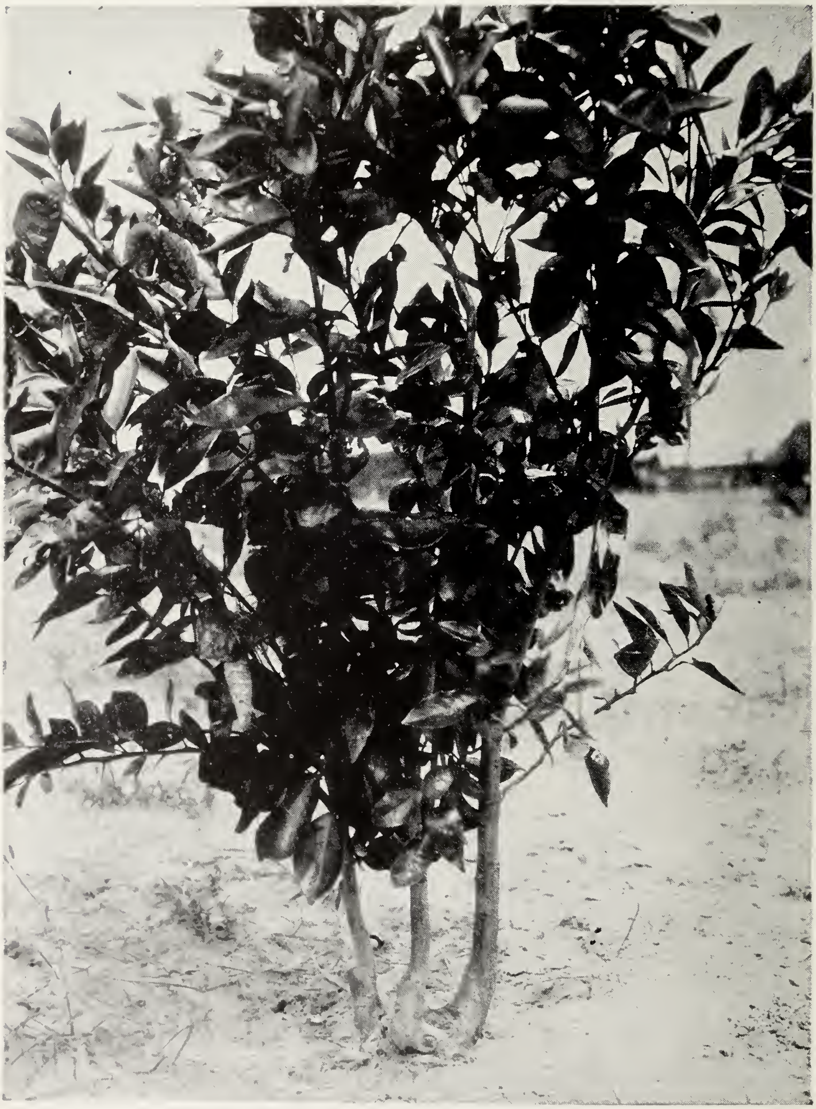

Fig. 24.—Budded sprouts from the rootstock of a tree which was cut off at the ground. This is one method of top-working.

of callousing over the old stump. In acreage to be handled in this way, the trees of adjoining rows can be felled toward each other and one stake used for two trees and the alternate middles kept clear while the first sprouts are being budded and started. The old tops will produce some fruit during the period while they are left attached to the tree.

Trees budded on *Poncirus trifoliata* should not be cut off at the bud, since this rootstock will frequently fail to send up sprouts. Other common rootstocks usually send up sprouts quite readily.

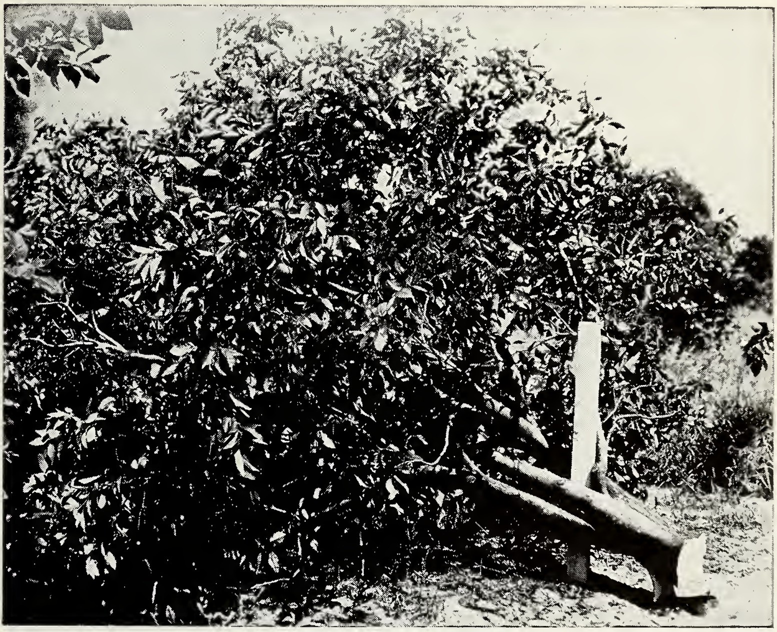

Fig. 25.—Tree partially cut through, felled and staked so as to support root system while sprouts are being worked.

The common method of top-working old trees is to cut them back to a framework, commonly called "hat-racking," and then to bud the sprouts which start on the limbs. On large trees it is common to cut back to a point where the cuts are through the limbs about 3 inches or more in diameter, but the exact point has to be determined by the wishes of the operator. The larger the framework left the more buds will have to be put in and the more old framework present which will have to be kept free of sprouts after the new top develops. On the other hand, the more limbs left the shorter the time necessary to get a new top on the trees. To keep down the amount of budding necessary and also to reduce the work of keeping the framework free of sprouts later, the cuts are usually made in large wood so as to leave four to seven large stubs and some time is sacrificed in getting the tree back into production (Fig. 26). The chief disadvantage of this procedure lies in the fact

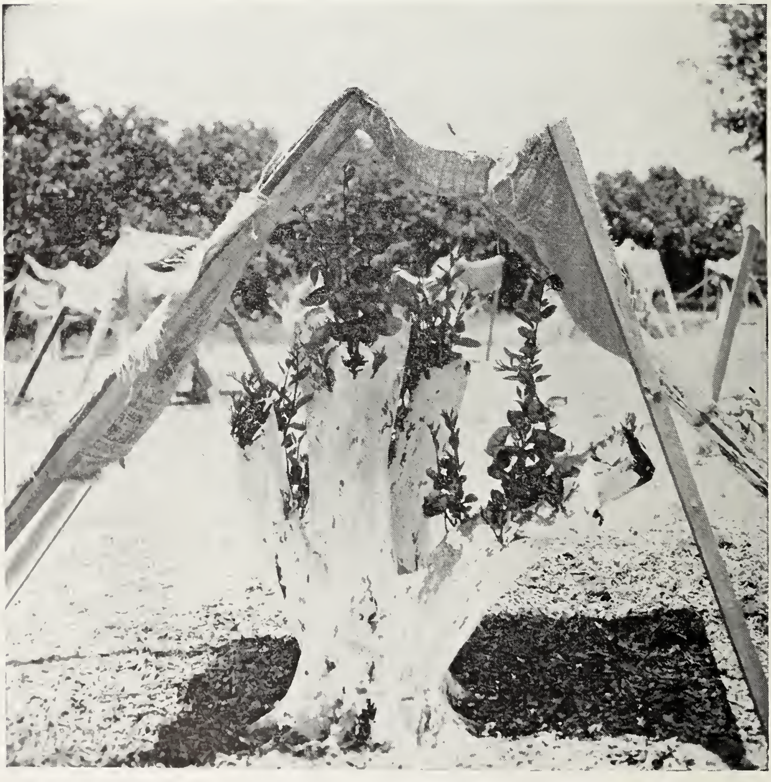

Fig. 26.—Large tree severely cut back preparatory to top-working. Sprouts protected by burlap shade.

that it is difficult to get large cuts calloused over and decay frequently sets in and seriously weakens the framework.

To reduce the shock to the root system, an excellent practice is to cut back about half of the limbs and to work these over and get the buds well started before cutting back the rest of the limbs. In doing this, it is best to cut a large limb on one side to permit access to the middle of the tree and then to cut off the central limbs (Fig. 27). After these have been worked to the new variety and a good top started (1 to 2 years) the remainder of the old top can be cut back and worked without danger of breaking up the new top while removing the limbs. This procedure is not usually followed as the grower is anxious to get the new top into production and considers it too much delay. It has the advantage, however, of keeping the root system in better condition and producing some fruit on the remaining old top during the period while the new top is being

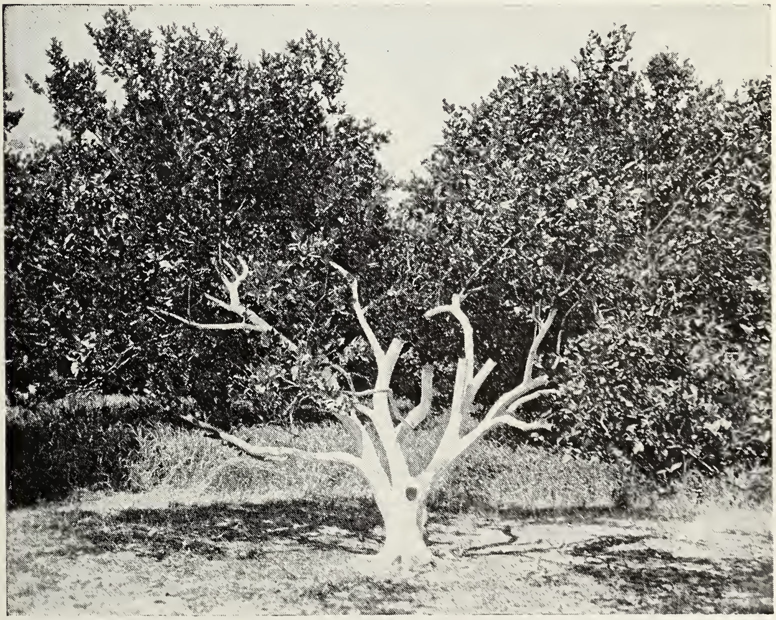

Fig. 27.—Large tree partially cut back preparatory to top-working in two stages.

developed. While this method is very seldom used, its advantages are such that it recommends itself highly as a general method of top-working.

In cutting back to a framework for top-working, the same general rules hold as for cutting back to the bud. Large limbs should be cut partially through on the side toward which they are to fall and the cut finished on the other side, as this prevents splitting. An alternative is to cut the limb off 1 to 3 feet above the point where the final cut is to be made and then to make the final cut at the proper point. The cut surface should be smoothed over and painted with grafting wax or a good wound dressing. The exposed framework and trunk should be painted with whitewash to protect it from the sun, otherwise the bark will be killed on the tops of the limbs. In addition, some growers protect the framework and the new sprouts with some sort of shade. This is usually a piece of sacking supported by some sticks tied to the framework (Fig. 26).

WHITEWASHES which will stay on a tree trunk or limb in this climate are difficult to make. Formulae for several durable whitewashes may be obtained from the Florida Agricultural Experiment Station at Gainesville or from the United States Department of Agriculture. A good but very old formula is as follows:

Quicklime	50 lbs.
Water	10 gals.
Salt	4½ lbs.

Slake the lime with the water in such a way as to prevent burning of the lime and then add the salt. This may be diluted to a suitable consistency for application. If it is to be used in a sprayer, it will have to be strained carefully and diluted more than would be necessary for brush application.

While the above formula is the old standby, it has been found possible to make an equally satisfactory whitewash using a fine grade of hydrated lime and adding zinc sulfate to it. In actual practice, it is best to dissolve the zinc sulfate in the water and then add hydrated lime to the desired consistency. A ratio of about 1 pound of zinc sulfate to 5 to 10 pounds of lime will be satisfactory. The amounts of lime and zinc sulfate are not extremely critical, but increased amounts of zinc sulfate will make the lime stick better than smaller amounts. This mixture will save slaking the lime and will stick as well as the old mixtures using quick lime and salt. In addition, the tree frequently seems to benefit from the zinc absorbed from the whitewash. For putting on with a brush, make the mixture quite thick and for applying as a spray make it thinner and make two applications so as to get coverage.

The limbs will sprout freely and after the sprouts have hardened up they can be budded by following the same procedure as for nursery stock. Not all of the sprouts should be budded and some thinning will have to be done. Always bud some sprouts near the cut end of the branch so that they will aid in healing the cut surface, and other sprouts can be budded along the limbs, selecting such as will help in forming a well-shaped head on the new tree. After the buds have started the unused sprouts can be thinned.

Some difficulty may be experienced if the buds are put in before the sprouts have hardened up sufficiently. The large root system tends to push the growth vigorously and the buds may be easily "drowned" if the wood is too soft. Generally, it is safer to lop the top of the sprout after the bud has taken and to make the final cut later. It is also good practice to snip off the tip of the sprout at the time the bud is put in. After the buds have started it will usually be necessary to provide some support to keep them from being broken off.

When trees are cut back, it is common to have the new growth develop "frenching" (zinc deficiency) and "die-back" (copper deficiency). If any signs of frenching or die-back appear, it is wise to spray the trees with the usual zinc and copper spray. Proper formulae for this purpose should be obtained from current spray programs.

A number of other methods can be used in topworking but the use of budding is generally preferred on account of the fact that a great many workers can do good budding but very few are familiar with the methods of grafting adaptable to citrus. These other methods are useful at times and for this reason a discussion of them will be given here.

When working large limbs, budding can be used directly on the limb if the workman is careful. In case the bark is reasonably soft and pliable, some form of shield budding can be used as previously described. Often the curved or angled incision will be found superior to the "T" for this purpose. When the bark is thick and will not "work" without splitting, it can be shaved and scraped to remove the outer hard layers and the inner bark left for "working." If the buds are slow to "take", a partial girdling of the limb above the bud or cutting back the top of the branch will help. This sort of budding is difficult and not recommended for ordinary use.

Bark grafting is occasionally used in working over stumps and large limbs. Its chief difficulty lies in a mechanical weakness of the union that may continue for some years. Like cleft grafting, it gains a year of time on sprout budding. For this type of grafting the stump or limb is cut off at a right angle to the axis and the cut surface smoothed up with a knife. Small scions up to 6 or 8 inches long are given a long slanting cut at the butt end and the sharp end shoved under the bark with the cut surface facing the wood of the stump (Fig. 28-A). Wherever possible a concave place in the contour of the stump should be used. If the bark is at all pliable the scion can usually be shoved under the bark easily, but where the bark is hard it may be necessary to make a short downward cut through the bark with the knife and to open the bark a little at the top before the scion is inserted. A brad or small nail may be used to help hold the scion in place. The stump is taped so as to hold the scions firmly in place and the cut surface of the stump covered with paraffin or grafting wax[1] to exclude air (Fig. 28-B). Several scions can be inserted, the number depending upon the size of the stump. This method is very convenient for working seedlings that have grown too long in the nursery and young trees that have been frozen to the ground. The new growth should be staked and saved from too much mechanical stress until a strong union is established.

Cleft grafting is a standard method of top-working for many types of trees and the results are excellent, but the work is slow and tedious by comparison with other methods of working citrus. It has one advantage in that the work can be done when the bark will not "slip." For this work a grafting iron is needed with which to split the stub of the limb or trunk (Fig. 29-A and -B). The cut is made squarely across and smoothed up as for bark grafting. It is then split longitudinally with the iron and a mallet. Orangewood does not always split smoothly and in careful work it is desirable to make a cut through the bark and into the wood on each side of the stub with a knife, giving a smooth cut where the scion is to be inserted. This can easily be done by placing the edge of the knife as in Fig. 29-A and hitting it a sharp blow with a mallet. Care must be taken to get the cuts on the opposite sides of the stub accurately in line if 2 scions are to be used. The grafting knife is then placed across the stub, lined up with the 2 initial cuts

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[1] Hume gives the following formulae for grafting waxes:

(1) Rosin, 6 pounds; beeswax, 2 pounds; linseed oil, 1 pint.

(2) Rosin, 4 pounds; beeswax, 2 pounds; tallow, 1 pound.

Directions for preparing them are briefly as follows:

Break the rosin into small pieces, cut up the beeswax and place the two together in a suitable iron pot. Pour the linseed oil over them, or in case recipe No. 2 is used, place the tallow on top. Set the pot over a slow fire and allow the materials to melt. Afterward remove from the fire, pour into cold water, grease the hands and pull until it is light colored.

If a liquid wax is desired, take 1 pound of rosin and 2 ounces of tallow, melt them together and mix thoroughly. Remove from the fire, cool slightly and add slowly 6 ounces alcohol and 1 ounce spirits of turpentine. Keep tightly corked in a wide-mouthed bottle. Apply with a brush.

Paraffin is very convenient to use instead of grafting wax and a portable lamp or lantern is manufactured which will keep a small pot of it in the melted condition. Paraffin is frequently of too low a melting point for satisfactory use in the open in Florida. This difficulty can be corrected by adding 3 percent to 5 percent of carnauba wax to the paraffin. For application, the paraffin should be just hot enough to keep it melted; if too hot it will injure the tissues of the plant.

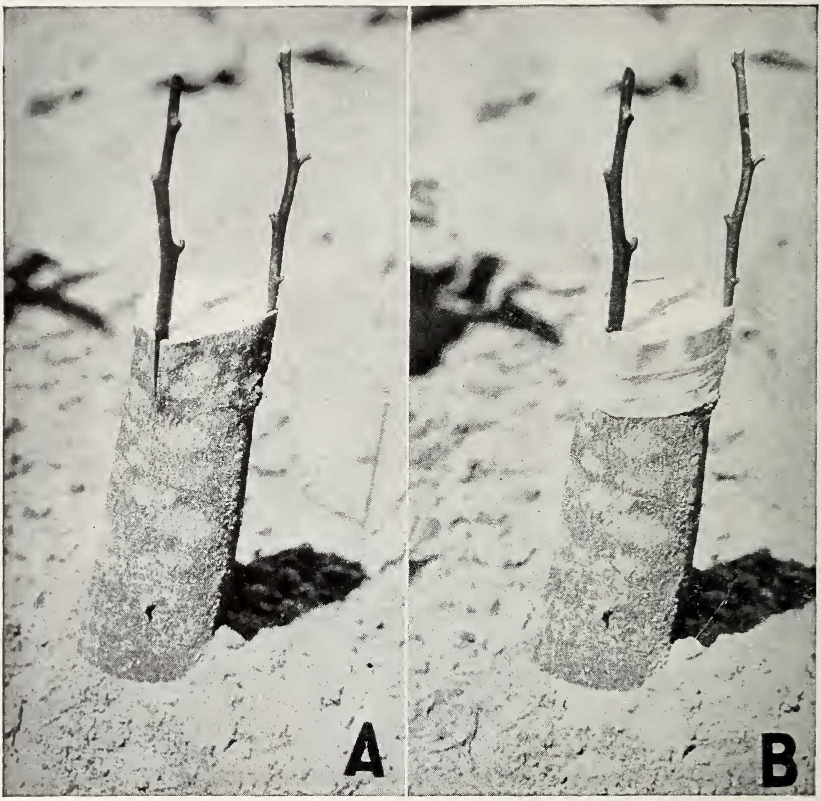
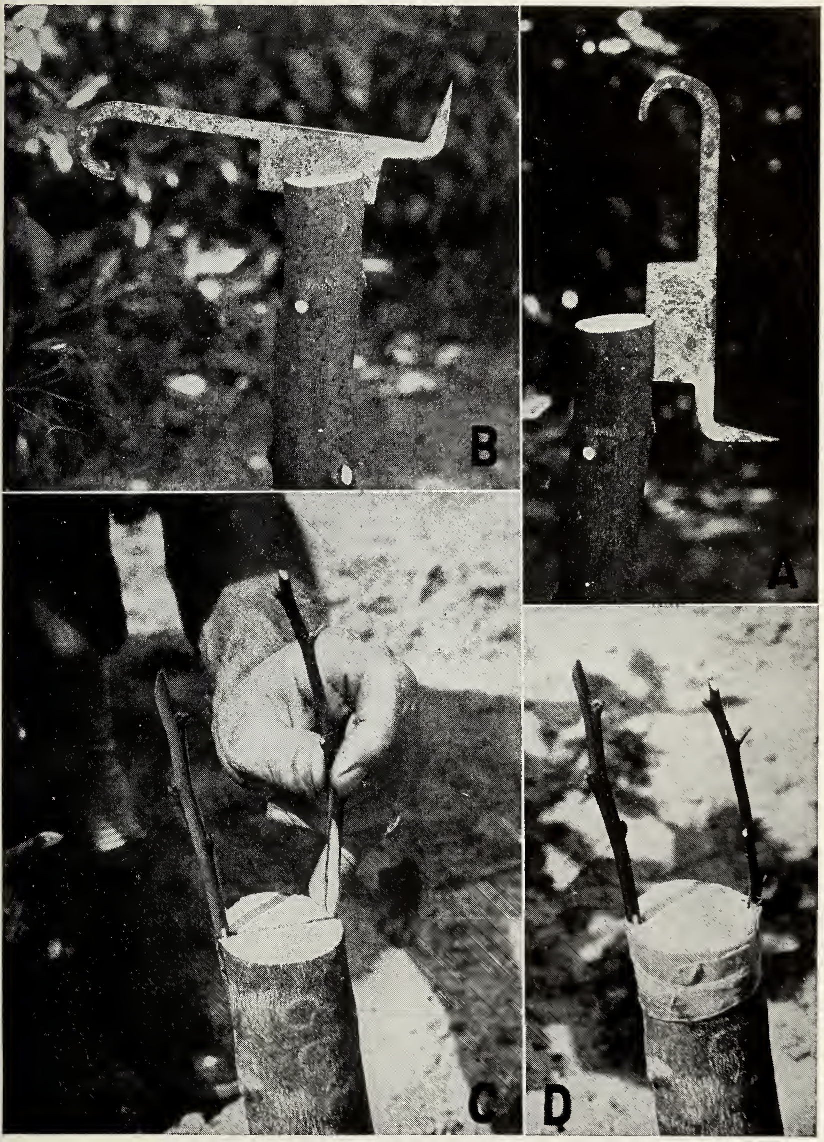


Fig. 28.—Bark grafting. A, scions in place; a brad driven through the scion into the trunk will help to hold the scion in place. B, bark graft taped and ready to be waxed.

and the splitting is accomplished with the aid of the mallet (Fig. 29-B). The split is then wedged open by the use of the wedge end of the mallet or a wooden wedge cut for the purpose. The scions should be 6 or 8 inches long and cut with a budding knife to a long wedge at the butt end (Fig. 29-C). These wedges should be slightly thicker on one side than on the other. The scions are inserted in the split and the cambium of the scion and the cambium of the stock carefully matched, with the wood of the scion against the wood of the stock. The thick edge of the wedge should be the one lined up with the cambium, as this will bring the pressure at the point where it is needed. After the scions are in place, the wedge in the stub is removed, the stub taped and the cut end covered with grafting wax or paraffin (Fig. 29-D).

This type of grafting gives the union a great deal of mechanical strength from the start and on this account

Fig. 29.—Cleft grafting. A, splitting the stub down the side; this gives a smooth cut for insertion of scion. B, splitting the stub. C, inserting scions. D, scions inserted and stub taped and ready for waxing.



is sometimes used in working over large trees. Frequently the pressure exerted on the scion will be so great in large stubs as to tend to pinch the scion off. Where this is likely to happen a wooden wedge should be left in the split to help ease the pressure on the scion.

Success in any of the methods of grafting lies in the careful carrying out of certain basic principles. Once the cutting is started, finish up as rapidly as possible so that the cut surface will not dry out. Be sure that the cambium of the scion and the cambium of the stock are held firmly in contact. Seal the wound thoroughly with grafting wax or paraffin. Do the work when the tree is in active growth; even cleft grafting is more successful under these conditions. If these things are done carefully the work will give good results.

Inarching

Difficulties sometimes develop that make it necessary to give a tree a new root system. This need occasionally is the result of an attempt to grow a variety on an uncongenial rootstock but more often is the result of foot rot or some other disease that girdles or partially girdles the trunk. It is possible under such circumstances to inarch seedlings or sprouts from the crown roots into the trunk and thus save the tree. This work is sometimes difficult and is not usually attempted unless the tree to be saved is valuable. Where the root system is sound and of a desirable type and sprouts can be induced to grow, these are to be preferred. Where this is not possible, seedlings can be planted around the tree and after they are established they can be inarched into the trunk. Seedlings are hard to start under the shade of large trees and require considerable nursing.

Where the trouble is not caused by a disease, as in the case of an undesirable rootstock, the inarching should be done as close to the ground as possible (Fig. 30-A), but where it is a matter of saving a tree attacked by foot

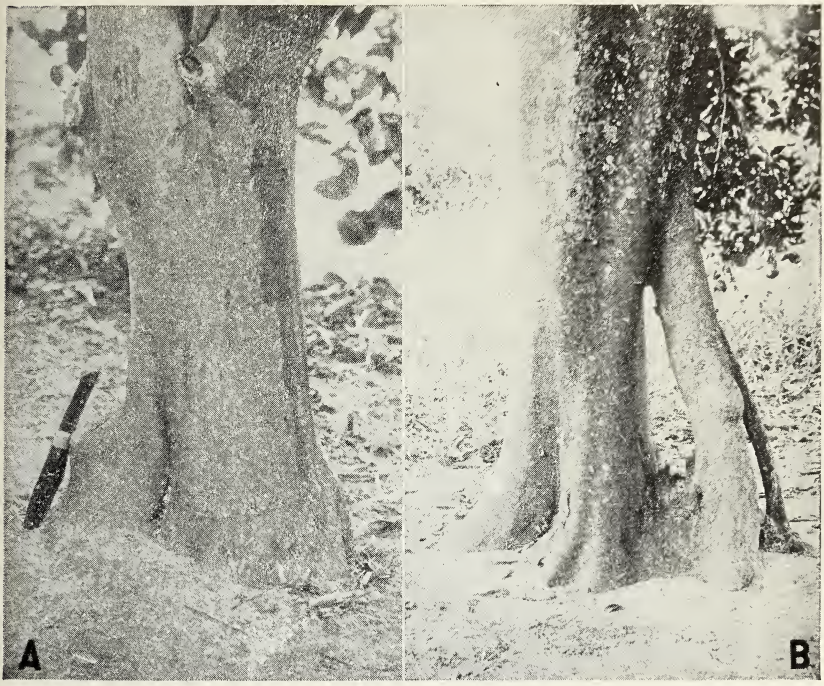


Fig. 30.—Trees saved by inarching. A, Temple orange tree on rough lemon root inarched with Cleopatra Mandarin; the inarch at left was close to the ground and of a fine type; fruit borne on limbs above the inarch showed favorable influence of new root system. B, old seedling orange tree attacked by foot rot successfully inarched with sour orange.

rot the work should be done well above the lesion (Fig. 30-B). Foot rot is commonest on old seedling trees and under such conditions sour orange seedlings are to be preferred for inarching and sprouts from the sweet orange root should not be used as they are susceptible to the disease. If the tree to be inarched is headed low, the seedlings may be worked into the limbs instead of the trunk but it will be desirable to trim the trees up as much as possible to let light in to the seedling while it is becoming established.

Inarching is accomplished by making an inverted "T" incision in the trunk of the tree and opening the flaps of bark slightly with the wedge on the budding knife. The sprout or seedling is then cut with a long slanting cut at such a height that when it is inserted into the

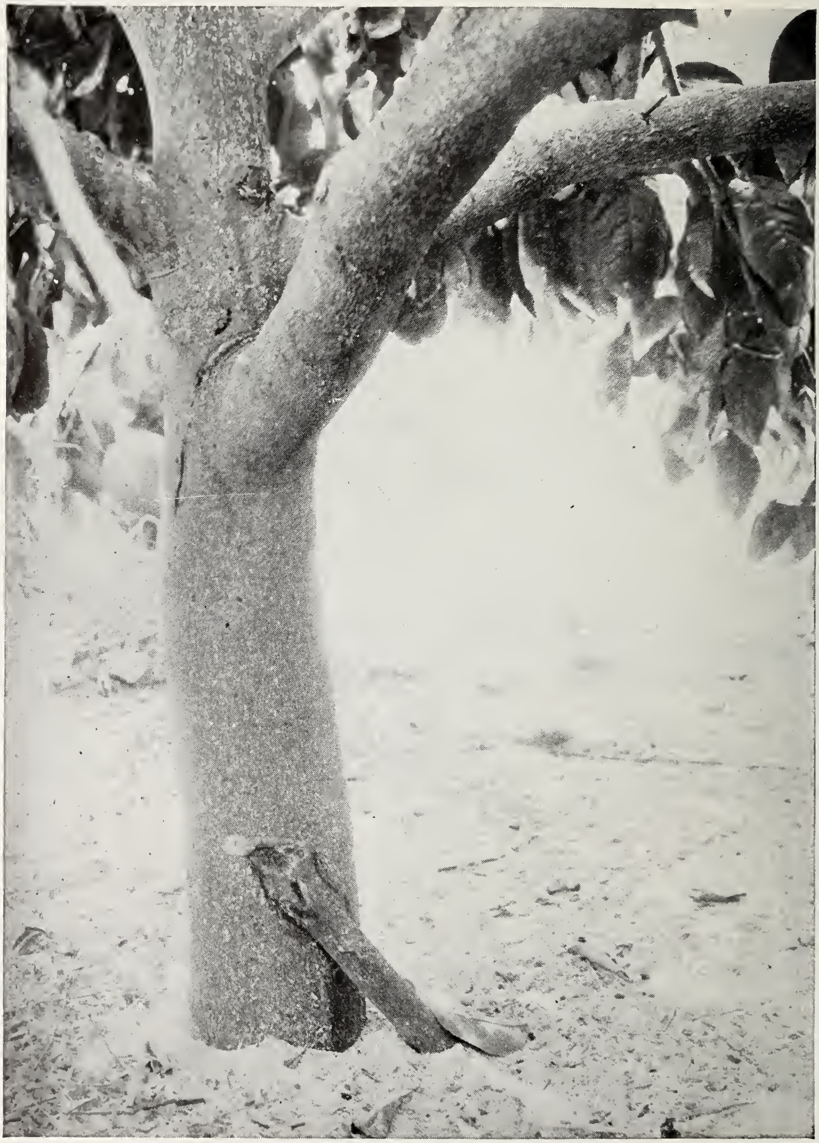


Fig. 31.—Inarched seedling put in at an angle to the axis of trunk, a procedure that is not recommended.

"T" slot the cut surface will be entirely within the bark and in contact with the wood of the trunk. The insertion is made by "springing" the stem of the seedling or sprout sufficiently so that the tip can be inserted under the flaps of bark and when the stem is straightened the tip will come to the proper position. As the stock tends to spring away from the trunk of the tree, it is necessary in most instances to secure it to the tree with a small nail or brad. This should be driven in so that the cut surface of the stock and wood of the tree trunk are held tightly together. The whole is then wrapped with budding tape, raffia or string to help hold it in place and the wound sealed with grafting wax or paraffin (Fig. 32).

The work will have to be done when the bark will slip and even then more or less difficulty will be experienced in working the bark. Scraping or shaving the bark to make it more pliable will help somewhat. If the work is done carefully and the wound thoroughly sealed, it will usually "take" and after several weeks the wraps can be cut but the seal of wax or paraffin should not be disturbed.

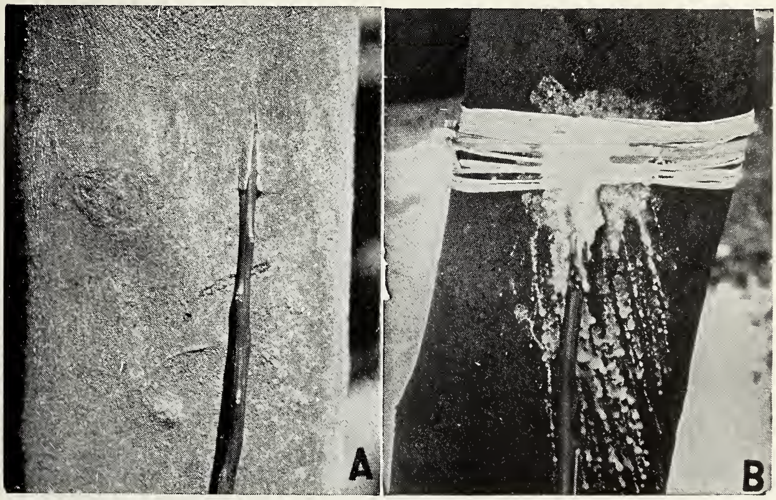


Fig. 32.—Inarching. A, seedling inserted in inverted "T" slot and bradded. B, inarch tied and paraffined.

Variations of the above method have been employed but in general most of these cause the wood of the stock and the wood of the trunk or limbs to be at a sharp angle to each other (Fig. 31), and results do not seem to be as good as with the above method. Observations indicate that best results are obtained where the stock and trunk are nearly parallel. This may be the result of a more natural flow of sap in such unions.

Scion Rooting

With the advent of tristeza, a method of scion rooting, sometimes called self-rooting, which permits the development of roots from above the bud union, has once again aroused interest. This has been recommended in this state at various times as a means of re-rooting seedling trees affected with foot rot or putting orange trees on their own root instead of on the root on which they were originally budded. It is of particular interest to growers having orange groves on sour orange root, because it offers a possibility for protecting them against tristeza if they can be successfully converted to sweet orange roots.

In order to accomplish this, the tree is partially girdled just above the bud union by taking out some oblong pieces of bark, usually ¼- to ½-inch wide and ½- to 1-inch long. These are distributed around the trunk so as to cause a partial girdle equal to ⅓ to ½ of the total circumference. Dirt is then mounded up around the tree to a depth of at least 3 or 6 inches (and preferably more) above the bud union and kept moist. Under favorable conditions, the tree soon starts to put out roots above the bud union and in the space of a year will have developed quite an extensive root system. Thus, if a sweet orange top budded on sour orange is rooted in this way, it will turn out as sweet orange on sweet orange. It is necessary to keep the soil moist and not allow it to dry out until the root system is well established and to this end, certain additions of soil will have to be made from time to time and watering done in dry weather. Past experience with this procedure on light sandy soils has not been too satisfactory because of rapid drying out of the soil and on heavier soils occasional trees become infected with foot rot; however, it can be done successfully and in the space of 2 or 3 years the girdle can be completed and the tree left on the new root system. The length of time required will depend upon the size of the top and the rapidity with which the root system grows. In case the work is done to protect trees on sour orange against the ravages of tristeza, it is necessary to start several years ahead of the time of infection since as soon as the trees become infected with tristeza, the sour orange root will begin to die.

The disadvantages of this method are the detailed work required in keeping up the mounds of earth and keeping them moist, plus the fact that the tap root rots after a while and this decay extends up into the trunk, leaving the tree with heart rot which severely weakens it in case of high winds. It is the sort of thing that small growers can do since they have opportunity to closely observe the trees and look after the mounds, but a type of thing that is difficult in large commercial operations where you have to depend upon labor crews. It can be recommended for the preservation of prize trees from the ravages of either foot rot or tristeza or, in small groves that can be closely supervised, it can be used as a protection against death of the trees due to tristeza if they are left on sour orange root. Figure 33 shows a self-

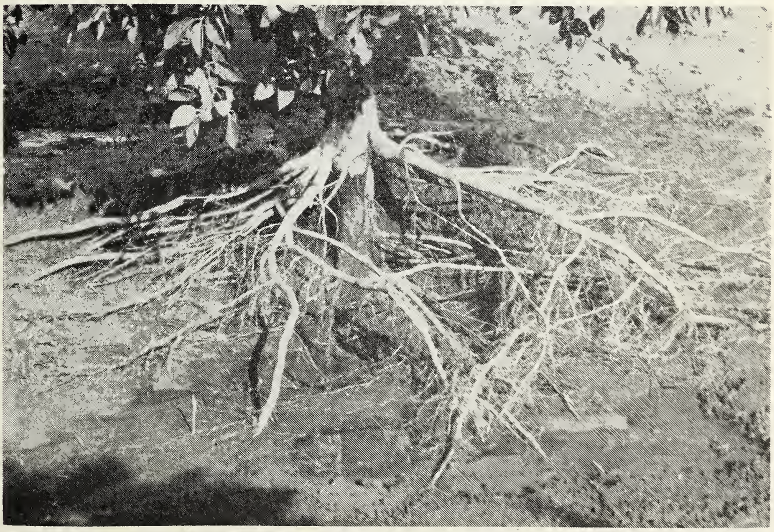


Fig. 33.—Scion rooted tree with the mound of soil washed away to show extent of new root system. Note that the old sour orange trunk and root system are dead and rotting away, the tree having become infected with tristeza. Picture courtesy of State Plant Board of Florida.

rooted tree with the mound of dirt washed away and it is to be noted that the original rootstock is decaying and this decay will probably extend up into the trunk of the tree unless the old stump is cut off in clean wood and the bottom of the trunk treated, a thing that is exceedingly difficult to do and should only be attempted for prize trees.

Transplanting Large Trees

The moving of large trees has become increasingly popular during the last few years and considerable acreage has been planted in this way. When done on a considerable scale, operators advise that they can transplant 10- to 15-year-old trees at from $1.00 to $1.50 per tree. While it involves considerable work, the large trees will come into bearing much sooner than young trees. Generally, however, the transplanting of large trees is limited to replacements in groves and for yard plantings.

Large citrus trees can be transplanted very easily if the proper precautions are taken, and there is practically no danger of failure. The amount of root system to be transplanted will depend upon the facilities for moving the trees and the trees should be dug with as little damage to the root system as possible. As soon as the tree is dug, the roots should be protected from drying out by wrapping with wet burlap or other covering and keeping them protected until planted. The new hole should be large enough to contain the root system easily and should be dug just before the tree is planted so that it will not have a chance to dry out. If possible, the surface soil and subsoil should be kept separate and some well decomposed compost and ground, steamed bone meal, if available, should be added to the soil as the tree is planted. Injured roots should be pruned off. The soil should be placed about the roots so as to leave them in a normal position and not bunched up. Water should be added as the soil is filled in; the soil should be made firm about the roots and a heavy final watering given. The tree should be given plenty of water until it is thoroughly established.

Methods of digging trees vary considerably, but the following method has been found very convenient. After topping the tree, dig a trench around it 18 to 24 inches deep, depending on the size of the tree, cutting all lateral roots (Fig. 34). From some point in the trench, dig deeply under the tree to cut the taproot at a level 2 feet or more below the bottom of the trench. Then, by using a crane or by hand, loosen the tree so that it can be lifted from the hole. (Fig. 35). The new hole is excavated evenly to the depth of the trench used in removing the tree and a post-hole digger or shovel used to make a hole in the center of it for the taproot. When the tree is

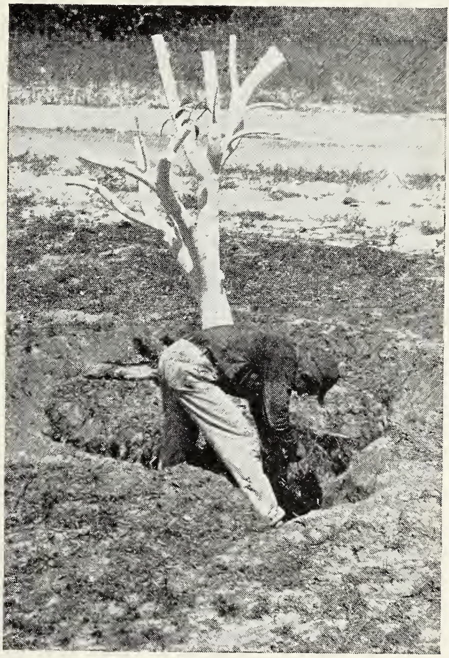


Fig. 34.—Severing tap root after all lateral roots have been cut. Whitewash has been applied as soon as the tree was cut back.

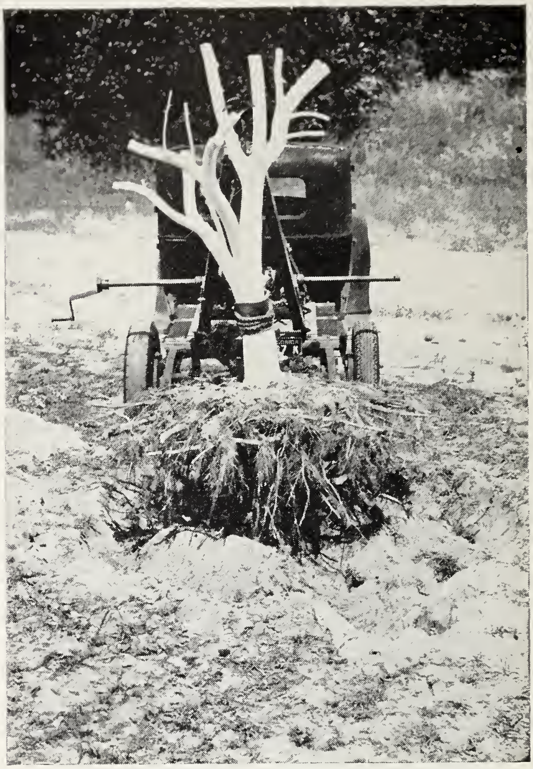


Fig. 35.—Tree being lifted by means of wrecking crane. If the tree is to be moved any distance the roots should be wet down and covered with a tarpaulin.

let down into this hole, the lower lateral roots will rest on undisturbed soil so that there will be less tendency for the tree to settle later (Fig. 36). There is also less disturbance of the subsoil than in the ordinary methods of excavation.

Trees can be moved during the winter when they are fairly dormant, in which case care will have to be used to keep them watered during the dry spring weather. Trees can also be moved at the beginning of the summer rainy season and will usually become established by winter.

The amount that the top will have to be cut back will depend upon the extent of the root system moved and the care taken in moving. If only a comparatively small

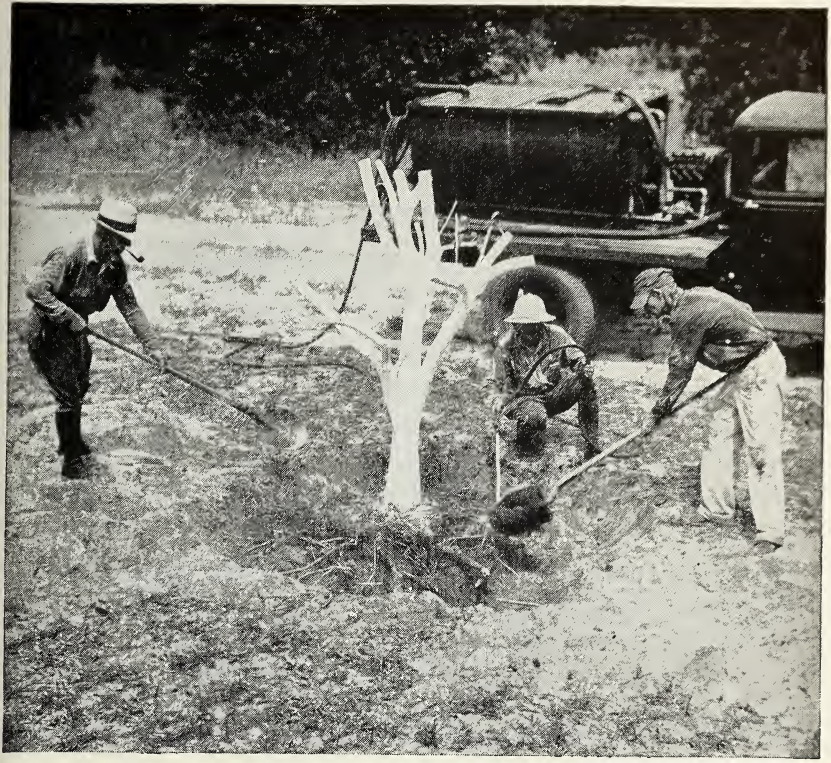


Fig. 36.—Water being used to wash soil around the roots and thus avoid air pockets. The use of plenty of water greatly enhances the possibility of the tree surviving.

root system is moved it is well to cut the top back to a framework, and protect the limbs from sunburning with whitewash. When trees are moved during hot weather, it is better to whitewash the framework before removing the top and to touch it up after replanting is completed. Sunburning of bark that has previously been in heavy shade can occur in a few minutes on hot days. Where large root systems are moved, less cutting back of the limbs will be required. Trees have been moved under favorable conditions without cutting them back at all, but the cost is too great for this to be generally practical.

Where it is desired to move large numbers of trees, an automobile wrecking crane mounted on a truck is very convenient or a simpler crane may be devised that can be attached to the ordinary truck. The arm of the crane can be attached to the trunk of the tree, with the bark protected by padding. As soon as the digging is completed, the tree can be lifted and a tarpaulin or large burlap covering wrapped around the roots and the tree moved quickly to the new location. It is easy to back the truck up to the new hole and let the tree down and hold it at the proper level while the dirt is being filled in.

PLANTING AND CARE OF YOUNG CITRUS TREES

The land on which young citrus trees are to be planted should be cleared as far in advance as possible, plowed and disked. If time permits, it is usually planted with *Crotalaria spectabilis* or some other leguminous cover crop for at least one season before planting the young citrus trees. The cover crop is either disked or plowed into the soil in the fall. Usually *Crotalaria spectabilis* is used for the purpose, and after it is grown for 1 year on the land it may be expected to produce at least 2 more good crops in young groves by natural reseeding, after which time it probably will not grow on light soils due to damping-off fungi. The land should be as smooth as possible and well-prepared before planting. Planting rough land which is full of old roots and stumps will lead to difficulties in cultivating and where oaks have been present on the land may result in the Oak Root fungus being transmitted to the citrus trees.

After these preparations, the land is usually laid off and staked for planting, and the spacings commonly used in recent years have been 25 by 25 feet for oranges and this or 30 by 30 feet for grapefruit. This spacing is proving to be too close on light soils and wider spacings such as 30 by 30 for oranges and 35 by 35 for grapefruit are excellent. In older groves closer spacing was common, such as 20 feet by 20 feet, but such close spacing has been found disadvantageous as the grove becomes older due to the crowding of the trees, and when this crowding occurs it is very difficult to maintain the grove in good condition or to produce first-class fruit. Spacings such as 15 by 30 feet are very desirable where the grower is willing to remove the alternate trees somewhere between the 10th and 15th year, but unfortunately this frequently presents too much of a mental hazard, and interlocking trees present a problem when the grove passes 20 years of age. For that reason, double planting is not widely recommended. Many other systems of planting have been used at one time or another, but today either the square or rectangular spacing is used.

The spacing problem is always a difficult one and usually results in a compromise. Basically it should be remembered that close spacing with large numbers of trees per acre gives much heavier early production, while wider spacings give better late production. Those who want quick production after planting a grove generally lean toward the closer spacings and those who are looking at the grove as a long-time investment generally lean to wide spacings. The Spanish accomplish both ends by very heavy hand pruning, planting frequently as close as 10 by 10 and keeping the trees pruned so that they just touch. Such spacings give very large numbers of trees per acre, with a 10 by 10 spacing giving over 400 trees per acre. Such a planting will have a very high yield at an extremely early age, but would require a great deal of hand work to keep production up over a long run, though this is done successfully under Spanish conditions. Such groves, however, are at great disadvantage when mechanical cultivation and spraying are done and are not at all practical under Florida conditions. A 20 by 20 spacing, which was standard years ago, gives 108.9 trees per acre, but when trees are budded on rough lemon, is too close for satisfactory operation of mechanical equipment by the 15th year; if budded on a slower growing stock, it may be satisfactory to the 20th year. A 25 by 25 spacing, which has been used for a great many years, gives 69.7 trees per acre and such groves are now having to be hedged in order to use mechanical spraying equipment. This is particularly true in the case of grapefruit. A 30 by 30 spacing gives only 48.4 trees per acre, but gives very fine production after 20 or 30 years of age but low production in the first 20 years. Such plantings are highly satisfactory for mechanical sprayers and other grove equipment. Plantings of 35 by 35 for grapefruit are even better in that regard but account for only 35.5 trees per acre, which results in extremely low production during the early years. Double spacings, such as 30 by 15, with 96.8 trees per acre, are very satisfactory in the early years, but will prove difficult to handle unless every other tree is taken out at about the 20th to the 25th year, leaving the trees 30 by 30 feet. Unfortunately, very few growers are willing to take out trees and the result is a hedgerow effect which is extremely hard to spray, cultivate and pick. There are a number of these combinations for growers who are willing to take out trees at the proper time, that will help to give both a high early production and a high late production, with a slight dip for 2 or 3 years at the time the alternate trees are removed. A 20 by 20 spacing, with 108.9 trees per acre can be thinned on the diagonal at 20 to 25 years to a 28.3 by 28.3 spacing with 54.4 trees per acre, which makes a very good spacing up to 35 years for oranges and about 30 years for grapefruit. A 30 by 20 spacing will give 72.6 trees per acre, which is about the same as the 25 by 25 spacing, but it is not quite so convenient for cultivation and some other operations, though highly satisfactory for spraying. A 35 by 17½ spacing will give 71.1 trees per acre and can be thinned to a 35 by 35 spacing later when the trees begin to crowd. A 25 by 25 spacing thinned on the diagonal to 35.4 by 35.4, with 35 trees, would be very satisfactory for Marsh grapefruit if the thinning were done by the trees' 30th year, but as aforementioned, getting growers to take out trees is an almost insurmountable problem. The present practice of hedging may make this unnecessary if the hedging is done consistently.

Generally speaking, the choices for spacing are about as follows: for a quick bearing grove that will show a profit early, a very close spacing with a high number of trees per acre; for a grove that will be at its best at 30 to 50 years of age or older, a wider spacing with less trees per acre; for a combination which will accomplish both, a spacing that is able to give a large number of trees per acre when the trees are young, followed by a thinning which will give a small number of trees and a wide spacing in the later years of the grove. The grower will have to make his own decision in this matter because much depends on his own reasoning in planting the grove. Some other factors need to be taken into consideration, however. Rough lemon stock makes bigger trees than sour orange or some of the other dwarfing stocks, so some attention should be paid to stocks. Poor drainage also tends to keep down the size of trees and spacing can be closer under such conditions. The above discussion, however, should give a grower some idea of the problem which confronts him and enable him to make a proper selection to suit his particular purpose.

In large plantings, it is commonly customary for the nursery selling the trees to do the planting and sometimes to take care of the new trees up to 1 year of age. In smaller plantings the trees must be cared for by the owner himself, and while a great deal may be done which will improve the growth of the young trees when planting a few trees in a dooryard, planting methods on a large commercial scale must be relatively simple. Trees are planted to best advantage during the winter, and probably the best period is during January and early February and up to the start of spring growth, but planting in the early summer is quite common.

In commercial planting, the common method is for the laborer to draw the soil away from the stake with a hoe to form a saucer around it about 4 to 6 inches deep (Fig. 37-A). After this is done, the stake is worked around in the hole to enlarge it and the taproot of the young tree is plunged into the hole after the stake is removed (Fig. 37-B). The dirt is then drawn over the lateral roots which have been spread out in the saucer around the stake (Fig. 38-C). This results in the lateral roots being in their natural position and not doubled up or crumpled. When they are covered, a basin is left around the tree for water (Fig. 38-D). Trees are watered immediately after planting and thereafter as necessary until they become established. In heavy soils a hole may be dug in the customary way and a planting board used, but in any event it is important not to have the roots any deeper than they were in the nursery, to have the soil well-packed around the roots, and the roots not doubled up or bent. Air pockets should be avoided, and the tree should be watered as soon as planted. When steamed bone meal is available, 2 pounds of it may be added to the dirt placed around the roots, but raw bone

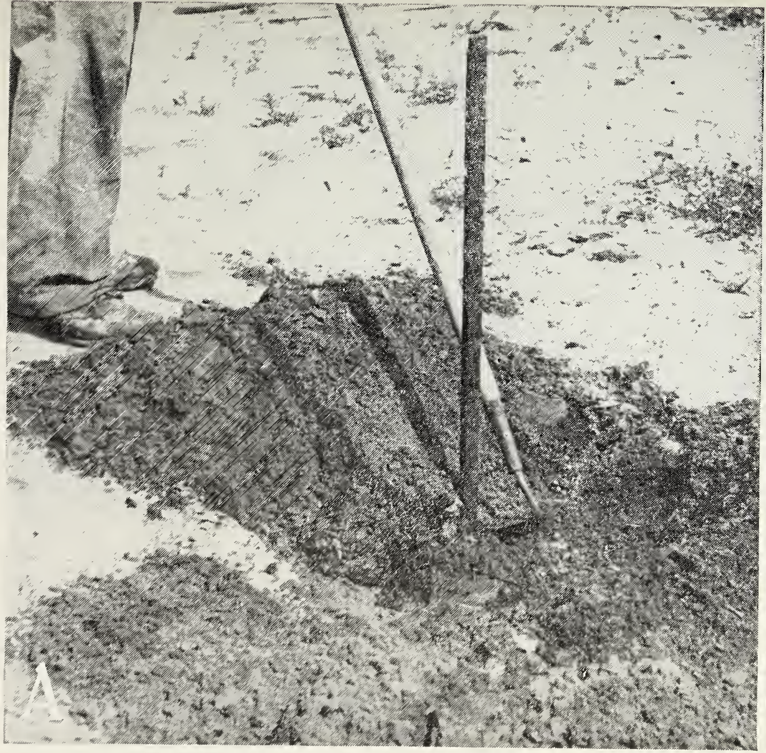


Fig. 37-A.—Drawing dirt away from the stake to form a basin for the roots.

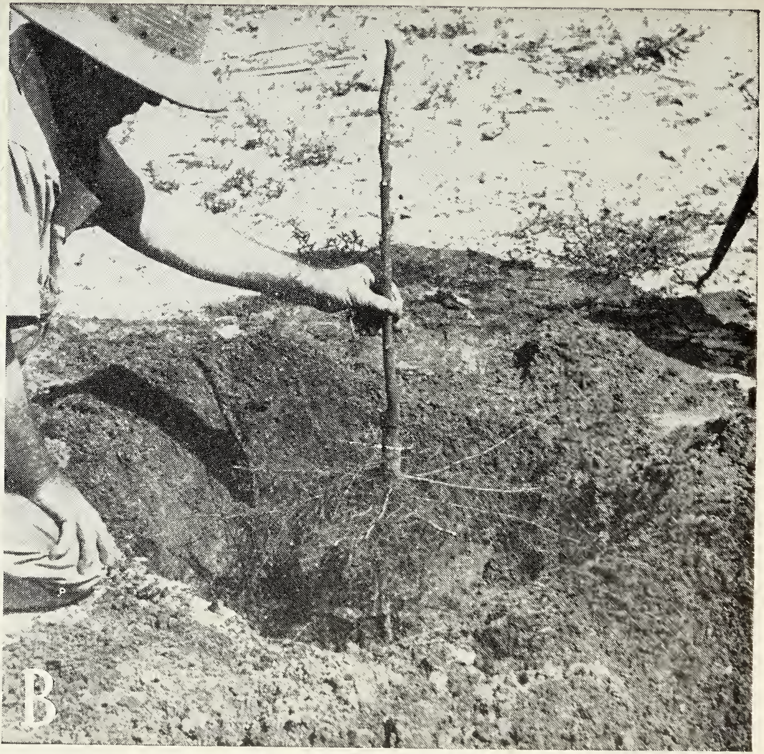


Fig. 37-B.—Inserting taproot in the hole left by withdrawing the stake.

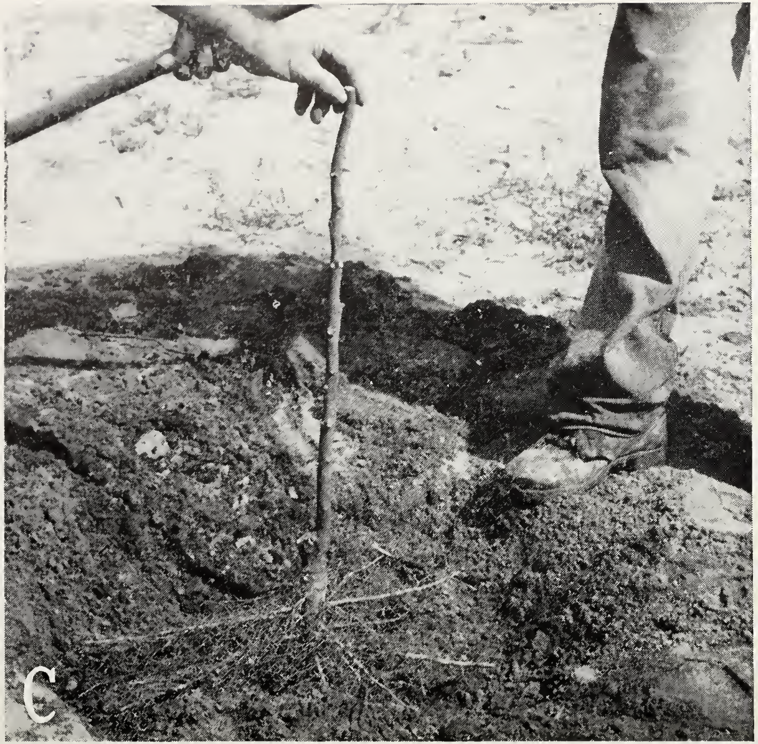


Fig. 38-C.—Planting citrus trees in the field. Covering root system by drawing up the dirt with a hoe.

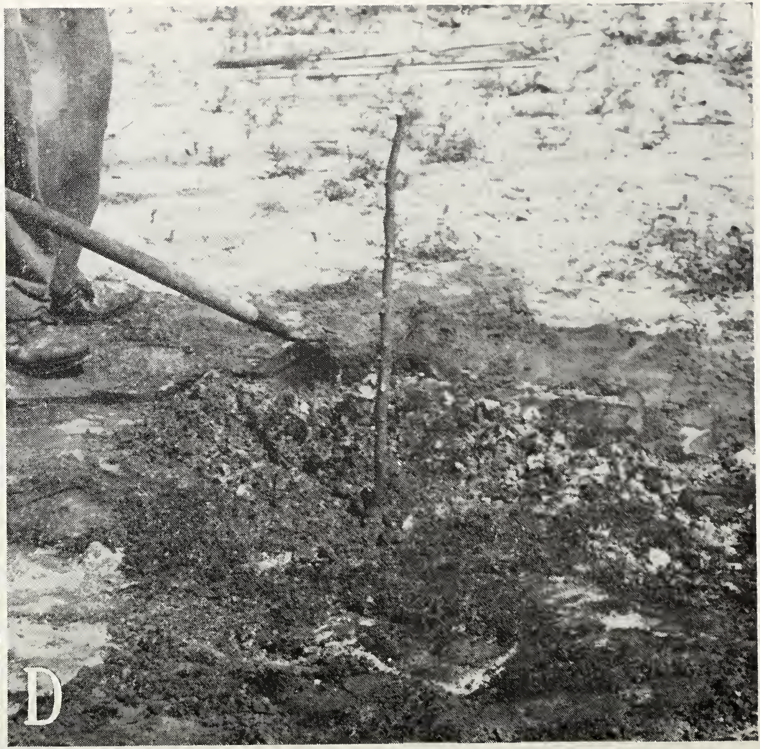


Fig. 38-D.—Forming basin around the young tree for watering. Trees should be watered well as soon as planted.

meal or other organic nitrogenous materials which are likely to heat should not be substituted for steamed bone meal as their heating is likely to kill the root system.

If the trees have been planted in the winter, they will start to grow with the spring flush of growth, at which time 1 pound of fertilizer should be added to the soil around the tree, covering an area slightly larger than the basin in which the roots were originally placed. In the past, it has been common to fertilize young trees only 3 times per year, using rather scant quantities because of the danger of die-back (copper deficiency). In recent years it has been found possible to avoid this by using the so-called minor elements freely, and under such conditions a tree may be grown very rapidly with the use of nutritional sprays combined with relatively large and frequent fertilizer applications. Under such conditions trees may be brought into commercial bearing 1 to 2 years sooner than they could be by the old methods of fertilization. The use of copper is particularly desirable in combination with large amounts of nitrogen, but soil applications alone of this element have not been found very satisfactory on young trees, perhaps due to the restricted root systems, and sprays have been found desirable as a supplementary procedure.

For young trees on acid sandy soils the following spray is suggested:

Copper sulfate	3 lbs.
Zinc sulfate	3 lbs.
Hydrated lime	4½ lbs.
Wettable sulfur	3 lbs.
Water	100 gals.

This combination should be made up by washing the copper sulfate snow into the tank as it is being filled. When the tank is about ¾ full, the copper should have all been added and the agitator is then started and the zinc sulfate dusted slowly into the tank after which the lime and wettable sulfur are made into a paste and washed into the tank through the screen while the filling is being finished. This spray should be applied about 3 times a year for the first 3 years. The first application is made as soon as the first growth on the newly planted tree has started to harden up a little and thereafter the applications are made just before each flush of growth, in the summer, fall and early spring. Roughly speaking the applications will be made at about the following dates: February 1, June 1 and September 15, with the exception of the first application the first year which, as above-mentioned, will have to await the development of some growth. The spray should not be applied to extremely tender foliage as it is likely to cause burn. Proprietary mixtures may be purchased which will eliminate the mixing problem.

When the above sprays are used the fertilizer may be applied about every 6 weeks using the old schedule of 1 pound for each year of age of the tree per application; i.e., the first year the applications will be of 1 pound each and the second year of 2 pounds. Fertilizer applications should be omitted from November 15 to January 15. The fertilizer used should contain liberal amounts of manganese and copper and some soluble magnesium. Many formulas for young trees are available and are satisfactory if the proper amounts of magnesium, manganese and copper are added. Such analyses as 4-7-5, 4-6-8 and 4-8-6 are entirely satisfactory but the mixtures should also contain 2 to 3 percent soluble MgO, 1 percent MnO and ½ percent CuO. If a higher analysis mixture is used, such as a 6-6-6, the other elements should be increased approximately in proportion. When the trees are being pushed with extreme rapidity it is sometimes desirable to make a separate application to the soil of *coarse granular bluestone* at about ¼ pound per tree. When newly cleared land is being planted, it is also desirable to make a general application of dolomite at 600 to 1,000 pounds per acre broadcast either just before or just after the trees are planted.

On lands that are alkaline, as are many soils in the coastal areas, manganese sulfate at 3 pounds per 100 gallons should be added to the spray mixture with an extra pound of hydrated lime to neutralize it. On such soils also the use of manganese sulfate in the fertilizer is usually of little value at the levels indicated but a separate application of 5 pounds per tree during the second year may be helpful though it is usually better to depend on the spray as the soil ties up the manganese rapidly when the pH is above 7.0.

When such a program as is indicated above is used, a close watch should be kept for scales, and if they start to develop spray with oil emulsion or add parathion to the nutritional spray. In such groves spot spraying to eradicate new scale infestations just as they are starting is frequently useful. DON'T LET SCALES ACCUMULATE IN YOUNG GROVES. A close watch of the grove at all times is indicated when the growing is being rushed but the rapidity with which profitable bearing is reached usually makes this extra care profitable.

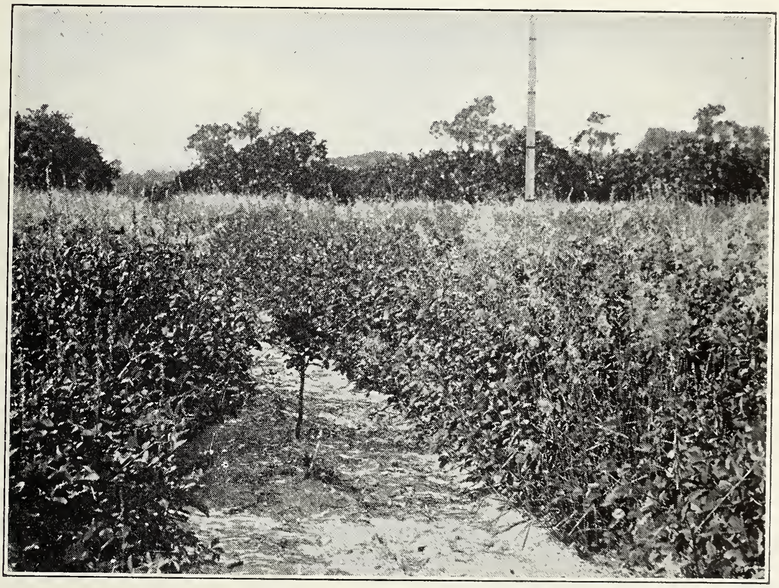


Fig. 39.—Crotalaria cover crop in young grove. Note the cultivated tree row.

Young trees are usually cultivated along the rows during the summer of the first 2 or 3 years in order to prevent the cover crop from encroaching on the trees. A mule-drawn cultivator or a small tractor outfit may be used to cultivate a strip about 6 feet wide on either side of the row while the middle is allowed to grow Crotalaria, hairy indigo or some other heavy-growing leguminous summer cover crop. No cultivation should be carried on except along the rows to keep the weeds and grass from encroaching on the trees.

The cover crop in the middles should be disked down in the fall to prevent it from holding back the drainage of cold air. Trees planted on the high sand hills of central Florida frequently suffer severely from dry winds during the winter and spring which carry sand which may literally sandblast the leaves from the trees or else cause severe damage. Under such conditions, it is desirable in the fall not to disk down all of the cover crop in the middles, but to leave a 2- or 3-foot strip in each middle undisked. This acts as a windbreak and prevents excessive drifting of the sand and its being carried in the wind. It is also desirable under such conditions not to disk very thoroughly the part that is being disked, but to do just enough disking to prevent fire hazard. A large amount of organic material from the cover crop lightly incorporated in the topsoil tends to hold the sand in place and prevent blowing. Care should be taken to leave the cultivated strips open ended so that cold air will drain away from the grove area and not be held back too much by the strips of cover crop that are left. If the strips run up and down the hill, make certain that the space between the strips is wide open at the bottom so that it will not hold back the drainage of cold air to lower land. In many cases groves are disked too thoroughly and no windbreak strips are left and the sand-blasting can set back the tree very severely if strong winter or spring winds occur, as they frequently do.

A watch will have to be kept for gophers and salamanders as these may do a great deal of damage to young trees. About November 1 the trees should be banked with clean sand free of organic matter to the height of about 12 inches in order to protect the bud and the lower part of the trunk against freezing. These banks should be pulled down just as soon as danger of

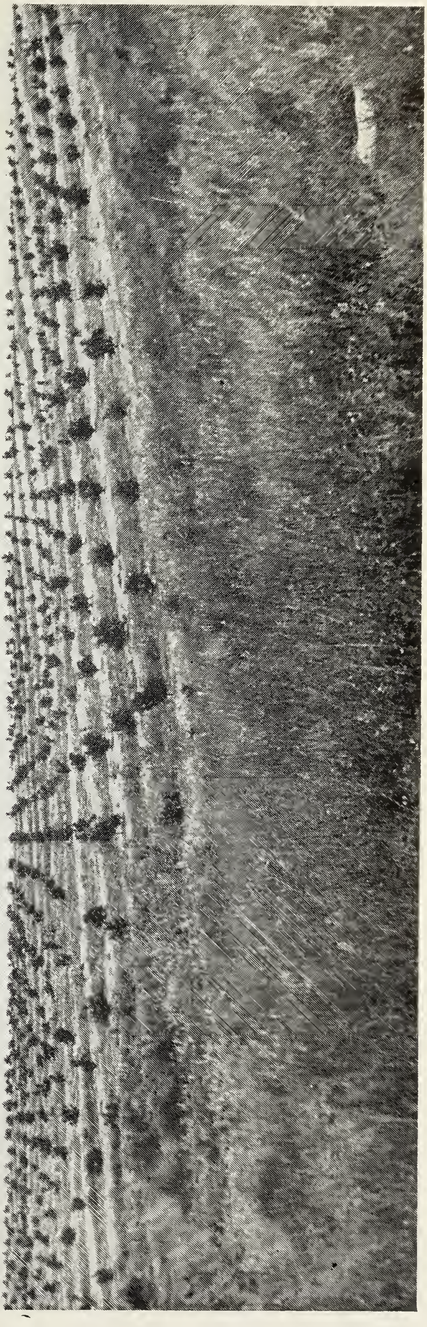


Fig. 40.—Young grove in second year.

cold is past as otherwise scalding of the trunks may occur in warm spring weather. Where labor is available it is well to wait to bank the trees until cold weather is expected in the fall, but where labor shortages exist it will have to be done in early November to avoid danger from an early frost.

Nursery trees as they are delivered for planting usually are cut back to about 24 inches. When planting it is common to cut them to a single trunk 12 to 18 inches high and thus remove all the framework. When they start to grow, the sprouts on the lower part of the trunks should be rubbed off frequently so that the shoots on the upper part of the trunk will form the framework of the tree. These are not thinned unless they become unusually thick, but if the lower sprouts are not rubbed off the upper sprouts will become weak and the trunk will have to be cut back. Occasionally some thinning of the sprouts on the upper part of the trunk is done in order to get a better formed top, but this is not usually done and the tree is allowed to grow freely and form a top naturally.

Young trees should be kept under close observation during the first 2 or 3 years so that trees attacked by gophers or salamanders may be promptly replaced, and also watch should be kept for scales if the spray program listed above is followed, and oil or parathion spraying should be taken care of promptly. There is also a caterpillar known as the "Orange Dog" which eats the leaves of young trees very rapidly and which must be picked off by hand.

By the time the trees have reached 4 or 5 years of age, they should bear a good crop if they have not been set back by cold or an irregular program of cultivation or fertilization. At this time they should be placed on the regular program for bearing trees.

CARE OF THE BEARING GROVE

Cultivation

In general, the cultivation practiced in citrus groves in Florida consists of allowing the cover crop to grow during the summer period when there is plenty of rainfall and no cold hazard. Because of difficulty in growing legumes for any length of time on most sandy Florida soils, the cover crop usually consists of native grass and weeds, and grows profusely enough so that it may be mowed at least once during the summer period or chopped with a cover crop chopper which consists of a large drum on which is mounted a series of knives (Fig. 41). Mowers or choppers are used to chop off the cover crop enough that it will grow a second crop rather than go to seed, whereas disking would kill the cover crop. During the fall after the rains are over, the cover crop is either disked into the topsoil or plowed under.

The general purpose of this cultivation is to eliminate the competition for moisture during the fall, winter and spring period when the weather is dry and to eliminate a fire hazard, as well as to eliminate ground cover which might interfere with the drainage of cold air during freezes. Disking and plowing are used interchangeably for this purpose but disking is a little cheaper. Plowing is usually done with a 3-bottom plow set to plow about 3 inches deep, but was formerly done with an 8- or 10-inch turning plow pulled by a mule. An offset grove disk is used for disking and on light soils is provided with spools or depth gauges to prevent it from going deeper than 3 inches. The disking need not be extensive but should incorporate the cover crop in the soil sufficiently to eliminate the fire hazard. The fall fertilizer is usually applied before the disking is finished and is worked into the soil by the disk. Where groves are plowed instead of disked, the fertilizer is usually applied after the plowing and may be worked in lightly with a disk which smooths up the plowing job which necessarily must be rough due to the interference of the trees. During the winter the Acme harrow is used if there are warm, moist spells in

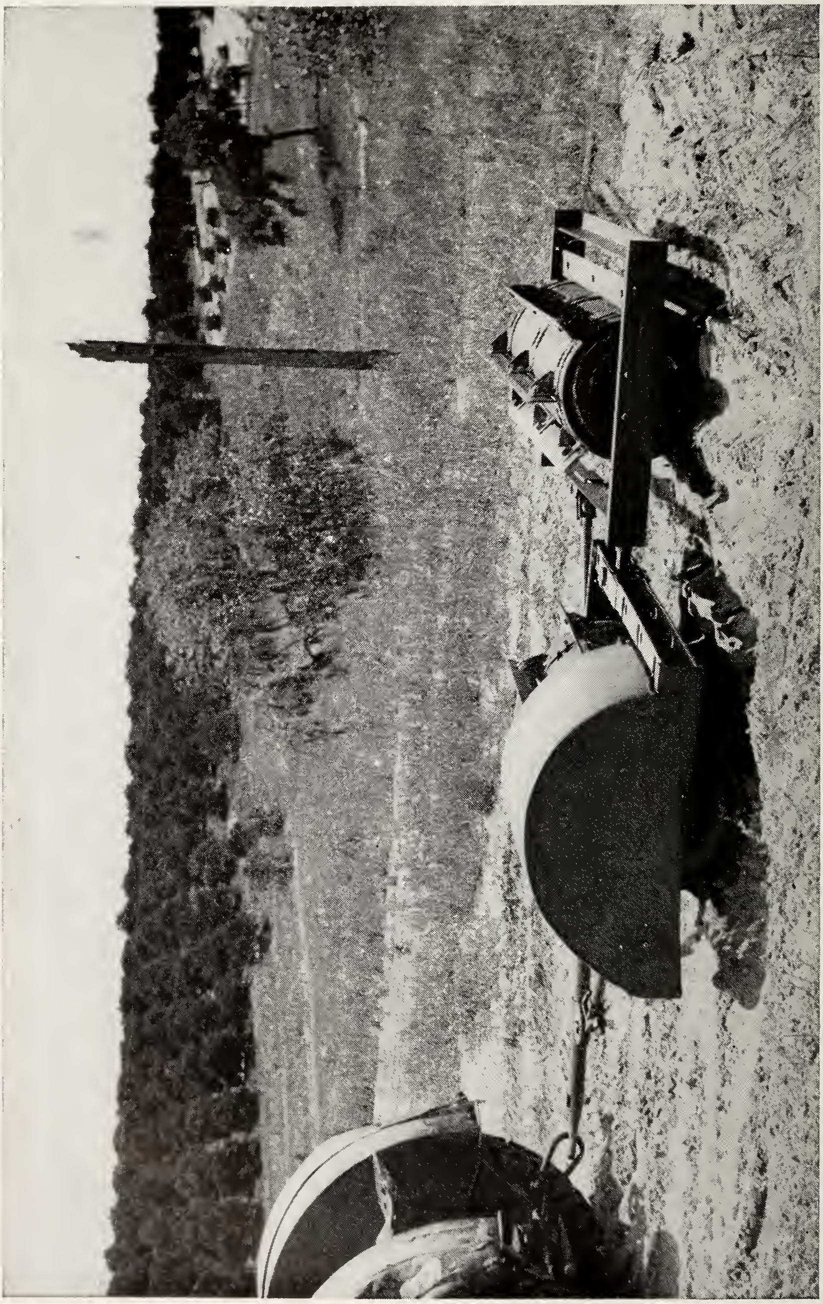


Fig. 41.—Cover crop chopper used to break down the cover crop in July to obtain a second growth. Used instead of a mowing machine.

which weed growth starts, as it is undesirable to have competition for moisture during the spring drought. When the cover crop starts to grow at the end of the spring drought, about mid-May, cultivation is abandoned for the summer as the destruction of the cover crop at that time might result in a cover crop failure for the year. It is always a little difficult to determine just when to stop cultivation in the early summer, but usually cultivation after the 15th of May is likely to be injurious if any rains have occurred by that time.

It is very important that an adequate cover crop be grown in all Florida groves during the summer period to protect the soil from the heat of the sun and also to maintain the organic matter content of the soil. As previously mentioned, these soils have a very low organic matter content and this organic matter is being constantly lost by oxidation. Cultivation during the summer period will greatly increase the loss and also prevent the replenishment of the soil with organic matter. Every effort should be made to get a good stand of cover crop in the grove during the summer period, and fertilizer is now applied generally in the middles as well as around and under the trees, in order to encourage the growth of cover crop as much as possible. On most sandy soils, where organic matter is of great importance, the legumes will only grow well for 3 or 4 years, after which time they will usually fail to make a stand. However, the natural growth of native grasses and various weeds will give excellent cover and a considerable amount of green manure. On new lands, as previously mentioned, *Crotalaria spectabilis* or *Crotalaria striata* may be grown as well as cowpeas, Alyce clover and hairy indigo. On heavier soils beggarweeds and other legumes will frequently grow year after year. In bearing groves, legumes may be dangerous unless disked or plowed early in the fall, as pumpkin bugs breed in them and may transfer to the trees and injure the fruit when the cover crop is killed by late disking or cold. During the last few years, hairy indigo has shown indication of being a very satisfactory cover crop in both young and bearing groves and it is being used increasingly. Not sufficient is known yet concerning its soil requirements and it has not been determined whether the soil will eventually become so infested with fungi as to prevent its growth, as is the case with other legumes that have been tried up to now. So far, it seems to have more resistance to this than any others that have been tried.

In former years it was the custom to hoe under the trees at least once a year in order to kill the weeds and stir up the soil. This practice was abandoned in the early '30's due to the expense, and unfortunately in most cases no effort was made to cultivate under the trees by offsetting the cultivation implements. As a result, the soil has become very dry under the trees in many groves and fails to wet satisfactorily during the rains or during irrigation. This should be taken into consideration and some hoeing should be done under the trees to stir up the soil and thus make it more easily wettable or else the ground under the trees should be cultivated by offsetting the disk or Acme harrow.

In some areas sod is used in the groves instead of cultivation, but it is usually found that this necessitates an increased amount of fertilizer as compared with a grove that is cultivated. However, this procedure can be followed successfully where there is a good supply of soil moisture and providing the grove does not have so much growth in it as to create a fire hazard during dry weather. In general in most locations in Florida, it is desirable to cultivate the groves during the winter.

Fertilization of the Bearing Grove

More divergence of opinion and more discussion can be raised on the subject of citrus fertilization than on anything else connected with the citrus industry, and there are almost as many different programs of citrus nutrition as there are people engaged in citrus growing. To the uninitiated, it appears to be a complicated and insoluble riddle. However, it is not as complicated as it may sound and often recommendations that appear to be widely different actually call for the same elements in approximately the same amounts. The tendency to discuss fertilizers is due, in part, to the fact that it is one of the largest cash outlays that the grower makes, and in part to the history of citrus fertilization in Florida. So many new elements and new practices have been introduced in recent years that the whole matter has not entirely jelled as yet.

In the early days of the citrus industry, groves were planted on better soils than those commonly used for citrus today. These soils have been abandoned, in large measure, because they were located in cold places, being mostly on the lower lands instead of on the tops of the hills where air drainage on cold nights gives a degree of protection against freezes. The early fertilizer programs included only the conventional nitrogen, phosphorus and potash, but these three elements were supplied largely in the form of natural organics such as seed meals, blood meals, animal tankage, bone meal, guano, tobacco stems and many other natural materials plus crude minerals. All of these contained a great many more things than the nitrogen, phosphorus and potash with which they were credited and mineral deficiences were not a serious problem.

The citrus industry was gradually forced southward by freezes and onto the high sand hills. These light sands were very low in natural fertility, but the organic mixtures worked reasonably well. However, more or less pure chemicals began to replace the natural organics and the crude minerals. High-grade sulfate of potash and high-grade muriate of potash replaced the crude products which contained considerable magnesium; superphosphate replaced bone meal which contained magnesium, manganese and at least a little of most of the other needed elements; and sulfate of ammonia, nitrate of soda and calcium nitrate replaced the natural organic sources of nitrogen. The changes in materials tended to eliminate the supply of practically all of the so-called minor elements. The situation that developed was extremely bad, with many of the groves affected by acute deficiencies of magnesium, manganese, copper and zinc and as a result producing poor crops of fruit, mostly of low quality. By 1930, it was clear that some very definite steps had to be taken to save the groves on the sand hills. As a result of research, it was found that most of the prevalent troubles could be corrected by the addition of magnesium, manganese, copper and zinc to the nitrogen, phosphorus and potash program and this program gave better results than the organic program formerly used.

This new nutritional program began to be put into extensive use about 1935 and was combined with a program for controlling the acidity of the soil. The sandy soils tended to become acid very readily due to applications of acid-forming fertilizer materials such as sulfate of ammonia plus the sulfur used for rust mite control. The application of the new program generally improved the situation: production increased, quality of fruit improved and costs of production went down materially.

The recommendations of that time were made against a background of research on corrective treatments and the recommendations have had to be modified from time to time. Further research has also added boron, molybdenum and an available form of iron to the list of elements recommended for use. Today citrus in some groves in Florida is supplied with all of the elements known to be needed by plants, including nitrogen, phosphorus, potassium, calcium, magnesium, manganese, copper, zinc, boron, molybdenum, iron and sulfur. No other area uses such an extensive list of elements in a nutritional program, nor are all of these used in the fertilizer in Florida, some of them being applied in the form of nutritional sprays for absorption through the leaves.

All of these changes coming about in the space of a few years has created very considerable confusion and has resulted in many presentations of the same idea as well as many diverse ideas.

Growers who have been with the industry for many years have been enormously impressed with the rapidity with which deficient trees respond to treatment and do not always realize that if a grove has been receiving for several years a complete treatment that is reasonably correct as to amounts, a reduction in the amount of an element may not show up in tree condition or cropping for several years. You could, for instance, take a grove that had been receiving liberal potash fertilization and eliminate potash completely from the fertility program and perhaps see no indication of potash deficiency for 4 or 5 years. When the deficiency does become acute, there is likely to be a sudden decline in tree condition and yield rather than a gradual decline. This is a rather general pattern for most elements. Many growers, not being aware of this, sometimes make sharp reductions in an element for one or two applications and, seeing no adverse effects, conclude that the element is not necessary, only to have to pay out a good deal of money to bring a grove back into condition later, after an acute deficiency has suddenly developed.

A deficient tree often will show very rapid response to proper treatment; a zinc deficient tree may visibly respond in 10 days to a zinc spray applied at the proper time, and iron deficient trees will frequently respond to a soil application of iron chelate within 2 or 3 weeks. On the other hand, groves that are in good condition nutritionally usually do not respond quickly to changes in the fertility practices. In general, the growers who have the least complaint about fertilizers maintain a steady, well balanced fertility program and those who have the most difficulties are those who vary their treatments widely, thus keeping the trees unbalanced nutritionally.

All growers who are attempting to handle the fertilization of their own groves, should become familiar with all of the deficiency symptoms known and the methods of correcting them. They should also learn something concerning what constitutes a good, workable nutritional program for their particular soil and their rootstock and variety combination.

Relation of Soils to Fertilizers

While there are a large number of soil types on which citrus is grown in Florida, there are two general categories with regard to fertility programs. The first and larger category includes the acid soils, mostly sands, and the second includes the alkaline soils, which mostly occur along the coasts and are alkaline because of a high calcium carbonate content.

There are many soil types in the category of acid sands, but the nutritional programs generally are fitted to the pattern of an acid, sandy soil with the amounts of applications varying, depending on the quality of the soil. The commonest soil types in this group are the Lakeland (formerly called Norfolk), Blanton, Eustis and Orlando.

The second category of soils includes mostly soils in the coastal regions which are alkaline due to the presence of excess calcium carbonate. Such soils may have a pH varying from 6.5 to 8.5 and this alkalinity affects the availability of many elements such as phosphorus, manganese, zinc and iron very markedly. The nutritional program for trees on these soils needs to be different from the program recommended for the acid, sandy soils. There are also some soils in the central part of the State that have been over-limed and on these the same nutritional program may need to be applied as to the coastal soils that are too high in pH. On the other hand, there are soils along both coasts that are not alkaline but acid in reaction and require a program approximately the same as that used in the sand hills.

It will be seen from this general discussion that the pH of the soil, or its active acidity, is a greater factor in regulating the type of fertility program used than is the soil type as such. In order to familiarize the grower with some of the problems related to fertilization of these two general categories of soils, somewhat more detailed discussion is given below.

ACID SOILS. These soils are usually sandy soils, frequently very deep sands. The top layer usually contains from 1 to 2% organic matter and below 1-foot depth the amount of organic matter is about one-third that in the topsoil. These soils have very little buffer capacity, that is to say, they do not resist change in pH, and acid fertilizer materials such as ammonium sulfate, ammonium nitrate and urea tend to lower the pH quite rapidly and this must be compensated for by applications of dolomite. Of the common nitrogenous materials used in fertilizers, nitrate of soda and calcium nitrate tend to raise the pH and most of the others tend to lower it. Sulfur used as an insecticide also eventually reaches the soil and is oxidized to form sulfuric acid, thus further increasing the acidity of the soil, and this also must be taken into consideration. If the pH is too low, that is, below 5.25, various troubles can be experienced that are related to this condition. Yellow spot, the symptom of molybdenum deficiency, very commonly occurs, as it did in the '30's, as a result of very heavy applications of ammonium sulfate to groves, and again in recent years when pH control was neglected. On many of these soils, bringing the pH up to 5.5 or 6.0 will take care of yellow spot, but will do so very slowly, so that unless molybdenum is applied, the effects of neglect of pH control can be felt for several years. Iron deficiency will also show up at these low pH's and will be particularly bad on some soils around lakes and swampy areas, and in "sand soaks".

The control of pH is usually accomplished by means of dolomitic limestone, but the amount applied per year depends on several things, including the amount of sulfur applied as an insecticide, the type and amounts of fertilizer applied, and whether dolomite is used as a filler in the fertilizer. During World War II and subsequently, dolomite was usually used as a filler in fertilizers, frequently to the extent of 600 pounds or more per ton, but following the war and a turn to more concentrated fertilizer mixtures, dolomite has largely been omitted and this amount must be added to the separate applications to be made. It is generally recommended that the pH of these sandy soils be brought to 5.5 to 6.0 by means of yearly applications of dolomite, but exact amounts can not be given, owing to variations in the amount of sulfur and the types of fertilizers used.

On acid soils that have a pH below 6.0 and above 5.25, most of the deficiencies can be corrected by soil applications of magnesium, manganese, copper, boron and sometimes zinc, though other factors seem to be involved in this situation as far as zinc is concerned. In general, a pH of around 5.5 gives about as good availability of the various elements as it is possible to obtain and keeps the number of elements that must be applied as sprays at a minimum.

Alkaline Soils. As previously mentioned, most of these soils are in the coastal regions and are alkaline because they contain excess calcium carbonate. Many of these coastal soils originally had an acid, high organic, top layer underlaid by either calcium carbonate rock or marl. Since drainage is a problem in such areas, it is necessary to bed, or ridge, these groves and in the bedding process the subsoil is mixed with the topsoil and the soil in the bed, as a result, is likely to be alkaline and may have a pH as high as 8.5 in some cases. Control of pH, that is the depressing of the pH to 5.5 to 6.0, is impractical in most of these soils because it would involve bringing into solution a great deal of calcium carbonate by the use of acid materials. Since some of these soils contain more than 50% calcium carbonate, this is obviously an impossibility. As a result, fertilizer programs are usually fitted to the pH, rather than attempting to change the pH of such soils, as is done in the sandy soils.

High pH brings on a great many complications as regards availability of various elements and the presence of a large amount of free calcium carbonate in the soil also adds to the problem. Copper, manganese, zinc and boron usually are applied as sprays on trees planted on such soils. Boron is usually available in such soils, but if copper, zinc and manganese have to be applied as sprays, borax might as well be added if boron is needed. Iron deficiency is very common on soils having pH's above 7.5 and sometimes is referred to as marl chlorosis, though marl chlorosis as it appears in the field is usually a mixture of iron, manganese and zinc deficiencies. While a treatment for iron deficiency on acid soils has been developed and is now widely used, there is up to the present time no recommended treatment for the correction of iron deficiency on alkaline soils, though research work is in progress on this point. Generally, iron deficiency on such soils occurs where the limerock is very close to the surface and such soils are of questionable value for citrus for other reasons besides iron chlorosis.

The presence of large amounts of calcium in the soil has a depressing effect on the intake of potassium and magnesium and this needs to be taken into consideration in setting up a fertility program. These three elements have mutually antagonistic actions and if any one of them is extremely high, the intake of the other two will be correspondingly reduced. Many of the limerocks in the coastal areas are rather high in magnesium and the problem of magnesium deficiency on such soils is not acute, but in some cases the limerock is almost pure calcium carbonate and deficiencies of magnesium can be very acute and considerable amounts of this element will have to be applied in the soluble form. Potassium applications probably should also be higher than they are in the central part of the State.

It should not be overlooked that there are many areas of acid soil in the coastal regions and that these are frequently acid sands not much different from those in the central part of the State and nutritional programs should be adjusted accordingly.

Nutritional Elements and Materials

Nitrogen is calculated as % N equivalent in fertilizer mixtures but was formerly calculated as % NH_3. It is indicated as the first figure in fertilizer formulae in Florida. Sources of nitrogen formerly were seed meals, tankage, guanos and nitrate of soda, but the sources commonly used today are ammonium nitrate (33½% N), sulfate of ammonia (20.5% N), nitrate of soda (16% N), urea (44½% N), nitrate of soda-potash (15% N and 14% K_20*), calcium nitrate (15% N) and organic materials such as sewage sludge, castor pomace and tankage. Most of the forms now used leave an acid reaction in the soil which must be taken into consideration in pH control. During the '20's and early '30's, amounts of nitrogen used were very high, often from .5 to 2 pounds per box of fruit produced. Most growers now apply nitrogen at 0.35-pound to 0.45-pound per year per box of fruit produced, though a common tendency is to use too much nitrogen and many growers will use 0.5-pound and higher.

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*This is a mined material and may vary in analysis, and the same is true of a number of other materials, so the figures given here are only approximations.

Phosphorus, commonly referred to as phosphoric acid, is calculated as % P_2O_5 equivalent and the percentage is the second figure in the fertilizer formula. Bone meal, either steamed or raw, was formerly the principal source of phosphorus and mixtures high in phosphoric acid were commonly used. Possibly the responses on which the use of these high phosphate mixtures was based were due to the magnesium in the bone meal rather than to the phosphorus. Superphosphate (18-20% P_2O_5) took the place of bone meal and this plus triple superphosphate (44-45% P_2O_5) is now the common source of phosphorus. Both of these are produced by treating phosphate rock with acid. Experimental work has shown that phosphate accumulates in the upper layers of soil where the pH is maintained at 5.5 or above and in many groves in Florida there is now a considerable reserve and the trees do not suffer when phosphate is withheld. Superphosphate is necessary for the utilization of nitrogen solution in making fertilizers and since solution offers the cheapest form of nitrogen, phosphorus is included in most fertilizers, usually at .2- to .3-pound P_2O_5 per year per box of fruit or higher in bearing groves. It is commonly used at high levels in young groves and is desirable for increasing the growth of the cover crop.

Potassium, commonly referred to as potash, is calculated as % K_2O equivalent in fertilizer mixtures and appears as the third figure in the fertilizer formula. Early sources of potash were kainit, low-grade muriate of potash and low-grade sulfate of potash. These materials contained considerable magnesium and responses resulting from the application of magnesium to magnesium deficient trees were probably mistaken for potassium responses and levels of potash in the older mixtures were consequently high. With the advent of the use of magnesium as such, the true role of potassium has been cleared up and amounts of potassium used have been gradually reduced. High-grade muriate of potash (60-

62% K_2O) is now the most commonly used source, while sulfate of potash-magnesia (22% K_2O and 18% MgO) is used as a source of both potash and magnesium. Presently used levels are from 0.3- to 0.4-pound of K_2O per year per box.

Magnesium, commonly referred to as emjeo, is calculated as % MgO equivalent and is the fourth figure in the formula. Magnesium deficiency was one of the very severe deficiencies in the '20's and early '30's. Actually the amount of magnesium needed by citrus approximates the requirement of phosphorus, so it can hardly be classed as a minor element. The common sources of soluble magnesium are crude magnesium sulfate (27-28% MgO) which is imported from Germany and sulfate of potash-magnesia (22% K_2O and 18% MgO) which is mined in New Mexico. Dolomite, which is used for pH control, is also a slowly soluble source of magnesium. The amount of soluble magnesium now commonly used is 0.2- to 0.4-pound of MgO per year per box produced.

Manganese is calculated as % MnO equivalent and is the fifth figure in the formula. The usual source of manganese for fertilizers is agricultural manganese sulfate containing 30.4% MnO. A deficiency of manganese is common on both acid and alkaline soils. On acid soils, manganese can be applied successfully to the soil, but on alkaline soils it is tied up too rapidly and is usually applied as a spray. On acid soils, manganese is usually included in the fertilizer at the rate of about .025- to 0.04-pound of MnO per year per box of fruit produced.

Copper is calculated as % CuO equivalent and is the sixth figure in the formula. The traditional source for fertilizers has always been copper sulfate (bluestone) containing 32% CuO, but recent work has shown that cuprous oxide is also a satisfactory source. For spray applications for either fungus control or nutritional purposes, Bordeaux mixture has been replaced by such materials as mono-basic and tri-basic copper sulfate and cuprous oxide. Availability of copper in the soil is related more to the organic matter in the soil rather than the pH, copper forming relatively insoluble compounds with the organic matter. Applications of copper were formerly high in relation to requirement in order to overcome this fixation in the topsoil. Copper has now accumulated in many of the older grove soils and the tendency is to reduce or eliminate applications entirely on bearing trees that have had a history of relatively heavy applications. It will still be necessary in fertilizers for young trees and for groves with low amounts in the soil. Rates of application, as a consequence, must be adjusted to the individual grove.

Boron is usually calculated as % B_2O_3 equivalent or may be given as pounds of *borax* per ton. The ordinary source is agricultural borax (44-46% B_2O_3). The use of boron is complicated by the fact that the margin between deficiency and toxicity is very narrow and a little excess can cause a great deal of damage. It is preferable to use it in a spring spray application at the rate of 1 pound of borax per 100 gallons, including it in one of the regular spray applications. When included in the fertilizer, the amount per box produced should probably not exceed .01-pound B_2O_3 per box per year.

Zinc is calculated for fertilizers as % ZnO equivalent. The source for fertilizers is usually mono-hydrated zinc sulfate (44% ZnO equivalent or 89% $ZnSO_4$) and this neutralized with lime is used as a spray. Recently neutral zinc materials similar to the neutral copper materials have begun to replace the sulfate in spray formulation. There are unsolved problems concerning the availability of zinc in the soil. In alkaline soils, the formation of insoluble compounds is readily understood, but in acid soils where it should be available, soil applications commonly fail to give results and sprays have to be resorted to, although applications of zinc sulfate to some acid soils will give satisfactory results. This can only be determined by trial in the actual grove since no chemical test has been developed to indicate whether soil applications will be satisfactory.

Molybdenum is recommended only as a spray and sodium molybdate is used and recommendations are on this basis. "Yellow spot", the symptom of molybdenum deficiency, was known for many years and its cause was only recently determined. Its occurrence is related to soil acidity; molybdic acid being insoluble under acid conditions. The sandy citrus soils of Florida are very low in molybdenum and when the soil becomes acid, the deficiency occurs. One ounce of sodium molybdate per 100 gallons of spray is recommended for mild cases of yellow spot or for maintenance, and 2 ounces for severe cases.

Iron is only recommended in the chelated form and poundages are usually calculated on the basis of the chelated form though materials of varying iron content are available. Iron deficiency has been known in Florida for many years on both acid and alkaline soils but applications of iron sulfate and other materials failed to give results. Recently it has been shown that iron in the chelated form will remain available to citrus on acid soils and correct iron deficiency. Two materials are available, one containing 12% iron and used on deficient trees at the rate of ⅓-pound of the material per tree and the other containing 8% iron and used at about ½-pound per tree per year. No recommendations have been made for alkaline soils.

Calcium is not indicated in fertilizer mixtures, but is applied incidentally in both superphosphate and dolomite. In many countries calcium is indicated in the fertilizer formula, but incidental application is depended on in Florida. Superphosphate contains not only mono-calcium phosphate but large amounts of calcium sulfate which is soluble. Dolomite is roughly half calcium carbonate and half magnesium carbonate while agricultural lime is an impure calcium carbonate. When either dolomitic lime or agricultural lime is applied to an acid soil, the acids in the soil are neutralized and calcium is adsorbed by the organic matter and a rise in pH results as well as the development of available calcium.

Sulfur is applied when sulfates of various fertility elements are applied, and large amounts are applied as dusting or spray sulfur which oxidizes in the soil to form sulfuric acid. On the basis of tree needs the application of sulfur is excessive, so it is not likely to become deficient in any foreseeable future.

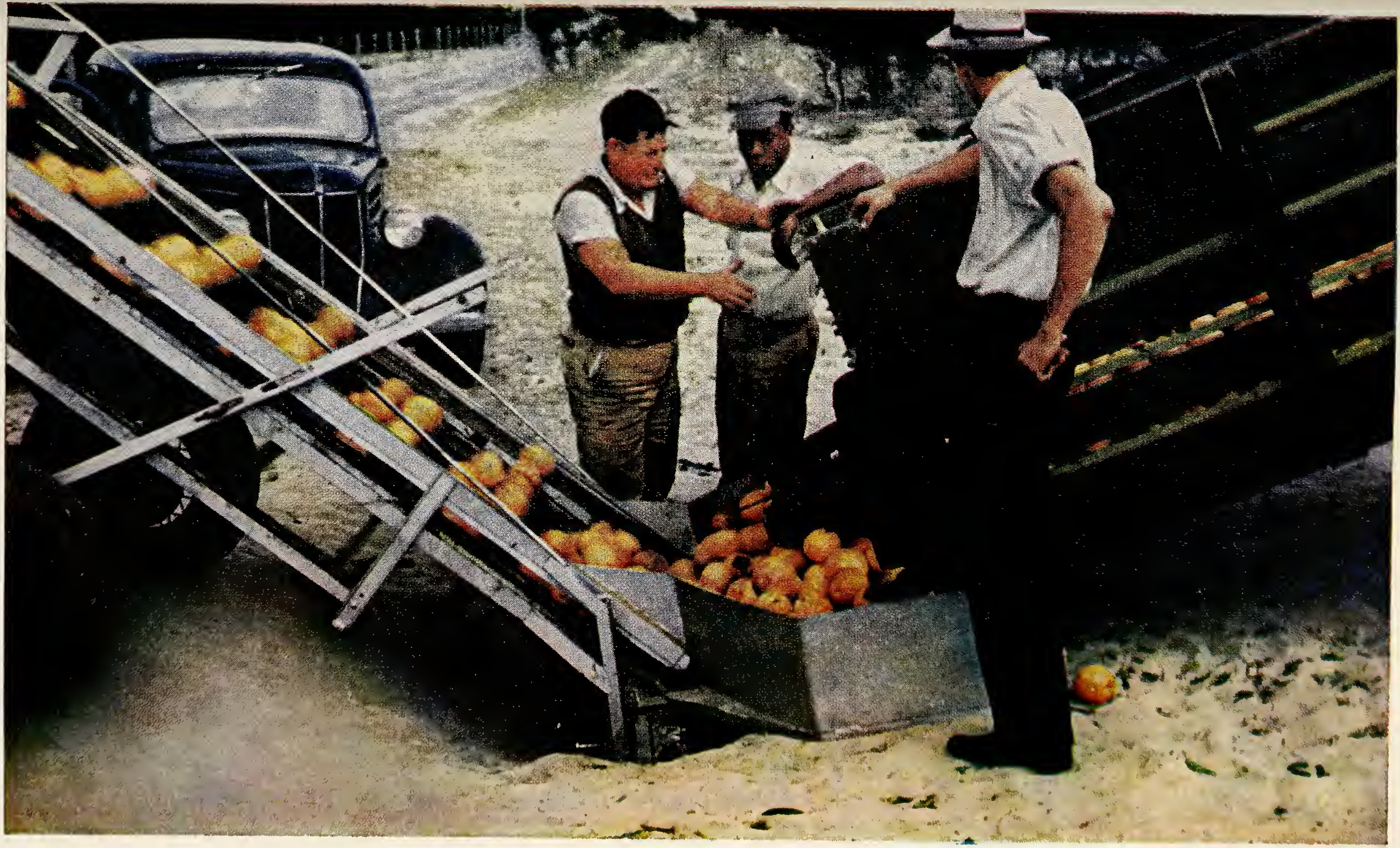
Fertilizer Mixtures and Their Use

Fertilizers are sold primarily as mixtures and the percentage content is given for each nutrient, so the above poundage figures which are now popular in some quarters mean little unless interpreted. If you take more or less average figures from the foregoing discussion, you will come out with a set of ratios somewhat as follows:

N	P_2O_5	K_2O	MgO	MnO	CuO
8	0	7	6	0.6	0
			or		
8	6	7	6	0.6	0

This represents the ratio for the yearly program and, if used as a fertilizer formula, the fertilizer would be applied at about 1⅔ pounds per box of anticipated production at each application. Citrus, however, is not as critical in its requirements as some would infer and widely varied analyses give good results. Since there is a wide variation in varietal and rootstock requirements plus a variation in soils and yearly weather, it is doubtful if a single best analysis will ever be achieved. As a consequence, variations from the above, such as an 8-6-8-6-.5-0 or 8-0-8-6-.5-0 or a 6-4-6-5-.4-0 or a 10-5-10-8-.75-0 or any one or a large number of approximate variations would give results that are not measurably different. Generally speaking, the percentage of K_2O should be slightly lower or equal to the nitrogen and the MgO about ¾ of the nitrogen, to approximate the above.

It is important to remember also that no one application is particularly important in itself, but must be considered in relation to other applications in the yearly program. The simplest program involves making three equal applications per year of a formula approximating the above ratios. However, many growers like to vary their applications either as to poundage or analyses or both and



BULK LOADING FLORIDA GRAPEFRUIT FOR PROCESSING PLANT

when they do this, they have difficulty in determining their actual yearly program. The commonest, though erroneous procedure is to average the analyses used. This is erroneous since it does not weight the averages for varying poundage at different applications. This is demonstrated in the following examples:

Time Applied	Fertilizer Analysis					Lbs. Fert. Applied	Pounds of Nutrients Applied (Lbs. of Fert. x % of Nutrient) / 100				
	N	P_2O_5	K_2O	MgO	MnO		N	P_2O_5	K_2O	MgO	MnO
Fall	12	0	10	6	.5	5	.6	0	.5	.3	.025
Spring	6	6	6	4	.5	10	.6	.6	.6	.4	.05
Summer	4	6	8	3	.25	15	.6	.9	1.2	.45	.0375
Total	22	12	24	13	1.25	Total Nutrients	1.8	1.5	2.3	1.15	.1125
Av. Anal.	7⅓	4	8	4.3	.41	Av. Nutrients	.6	.5	.766	.38	.0375
Ratios red. to 8% N.	8	4.36	8.7	4.7	.45		8.	6.7	10.	5.0	.5

It will be noted that P_2O_5, K_2O, MgO and MnO have all been applied at a higher rate than an average of the analyses would indicate.

Applications of straight nitrogen materials are frequently omitted by growers in figuring their yearly program and this can throw their program out of gear. They should always be included in the calculations as follows:

Time Applied	Fertilizer Analysis					Lbs. Fert. Applied	Lbs. Nutrients Applied				
	N	P_2O_5	K_2O	MgO	MnO		N	P_2O_5	K_2O	MgO	MnO
Fall	33.5	0	0	0	0	10	3.35	0	0	0	0
Spring	6	6	9	6	.5	20	1.2	1.2	1.8	1.2	0.1
Summer	6	6	9	6	.5	20	1.2	1.2	1.8	1.2	0.1
Total	45.5	12	18	12	1.0		5.75	2.4	3.6	2.4	.2
Av.	15.16	4	6	4	.33	Av.	1.916	.8	1.2	.8	.066
Ratios red. to 8% N.	8	2.1	3.2	2.1	.175		8	3.3	5	3.35	.028

Many growers using such a program are under the impression that they are using a 6-6-9-6 program when as a matter of fact they are low in both potash and magnesium in relation to nitrogen and their nitrogen applications are either excessive or their magnesium applications so low as to bring on a deficiency.

The difficulty in analyzing a program involving several different analyses of fertilizers often causes difficulty for even old experienced growers, since both the analyses and the poundage are usually varied, so some system of weighting the figures must be used as above. For new growers confronted with innumerable fertilizer analyses, it is usually better to standardize on one mixture that will adequately meet the tree needs and use it at all three applications. In any event, it should always be remembered that applications of straight nitrogen or high analysis top-dressers should be included in calculating the seasonal program.

Various methods have been proposed as guides for amounts of fertilizer to be applied. Diameter of the top was proposed in the '30's and discarded. This was followed by recommending so much fertilizer per box of fruit produced, making allowance for unusually short crops. A recent proposal is to base fertilization on the number of boxes the tree can potentially produce. This has the effect of substituting an hypothetical figure for a tangible figure and is weak to that extent, since both the grower and the fertilizer salesman are likely to be overly optimistic in estimating production potential.

It is now generally accepted that the fall and spring applications have little value for the current crop and are applied for the succeeding crop. This means that two applications are made for an anticipated crop and only one after the crop is actually set and its size can be estimated. In estimating the anticipated crop for the first two applications, the basis should be the production for the previous three or four years, corrected for probable increase in young trees or increases that can reasonably be expected on trees that have been definitely underfertilized. Groves that are in full bearing and have been well fertilized will not usually give production proportional to large increases in fertilizer applications. Increasing the fertilizer will not compensate for other limiting factors.

Based on the previous discussion and figuring on a full grown grove on rough lemon stock, about 1⅔ pounds of an 8% N fertilizer containing the proper proportions of the other elements would be indicated for each of the three applications as a per-box figure. If a 6% fertilizer is used, the figure would be about 2.2 pounds per box. Per-box figures on this basis for fertilizers and materials of varying nitrogen content are as follows:

% N in Fert.	4	6	8	10	12	16	20.5	33½
Lbs. Fert. per box	3.33	2.2	1.66	1.3	1.1	.83	.65	.4

In any discussion of amounts of fertilizer nutrients, it should be remembered that there is variation in requirements depending on soil, stock and variety, and applications should be adjusted accordingly. Rough lemon stock will produce more fruit per unit of fertilizer than sour orange stock; good soils require less fertilizer than poorer soils; Marsh Seedless is more efficient in utilizing fertilizer than seedy grapefruit and Parson Browns or Pineapples are more efficient than Valencias. All of these factors should be considered in varying the program.

Times of applications are usually adjusted to coincide with or precede growth flushes; thus, the spring application is usually made in January just prior to the spring flush, the summer application in May or early June just prior to the summer flush, and the fall application in September to November, corresponding with the fall flush. The relative poundages per application are the subject of endless discussion, but data on the subject are not clear cut and until better information is available, the grower might well divide his applications in three about equal portions. Many growers prefer to use one application of straight nitrogen or one of a top-dresser such as a 12-0-10 and two of complete fertilizer and in such cases the nitrogen or top-dresser can replace the fall or the spring application, though there are no data to indicate any superiority for this practice. When such a practice is followed, the two applications of complete fertilizer should be higher in potash, magnesium and manganese than the indicated ratios in order to compensate for failing to apply them in one of the applications, thus:

Time	Fertilizer Analysis					Lbs. Fert.	Lbs. Nutrients Applied				
Applied	N	P_2O_5	K_2O	MgO	MnO	Applied	N	P_2O_5	K_2O	MgO	MnO
Fall	16	0	0	0	(Nit. Soda)	10	1.6	0	0	0	0
Spring	8	0	12	8	.75	20	1.6	0	2.4	1.6	.15
Summer	8	0	10	10	.75	20	1.6	0	2.	2.	.15
					Amts Applied		4.8	0	4.4	3.6	.3
					Ratio for Season, basis 8% N		8	0	7	6	.5

Formerly, fertilizer was applied by hand with the laborer spreading it from a bucket in a ring around the drip of the tree. This starved the cover crop and also resulted in a concentration of tree roots in a narrow circle. The practice today is to spread the fertilizer from trunk to trunk and trees today root throughout the middles.

Fertilizers are usually applied using mechanical spreaders (Figs. 42 and 43). These spreaders feed the fertilizer mechanically onto spinning discs which throw the fertilizer centrifugally from trunk to trunk. They have obvious disadvantages: they throw too much fertilizer on the trees, and they tend to unmix the fertilizer by throwing the heaviest particles under the tree and leaving the light, fine material close to the track of the spreader. A better spreader is badly needed.

The control of soil acidity (commonly referred to as pH control) has already been discussed in theory and on the sandy soils should never be overlooked. Applications of dolomitic lime are usually used for this purpose but exact poundages can not be specified because they depend on soil composition, fertilizer practice and the amount of sulfur used for mite control. The latter is important since 1 pound of sulfur requires about 3⅛ pounds of dolomite to neutralize it after it has been oxidized. If a grove is under a heavy fertilizer program and receiving around 500 pounds per acre of sulfur per year, 1500 to 2000 pounds of dolomite or more may be re-

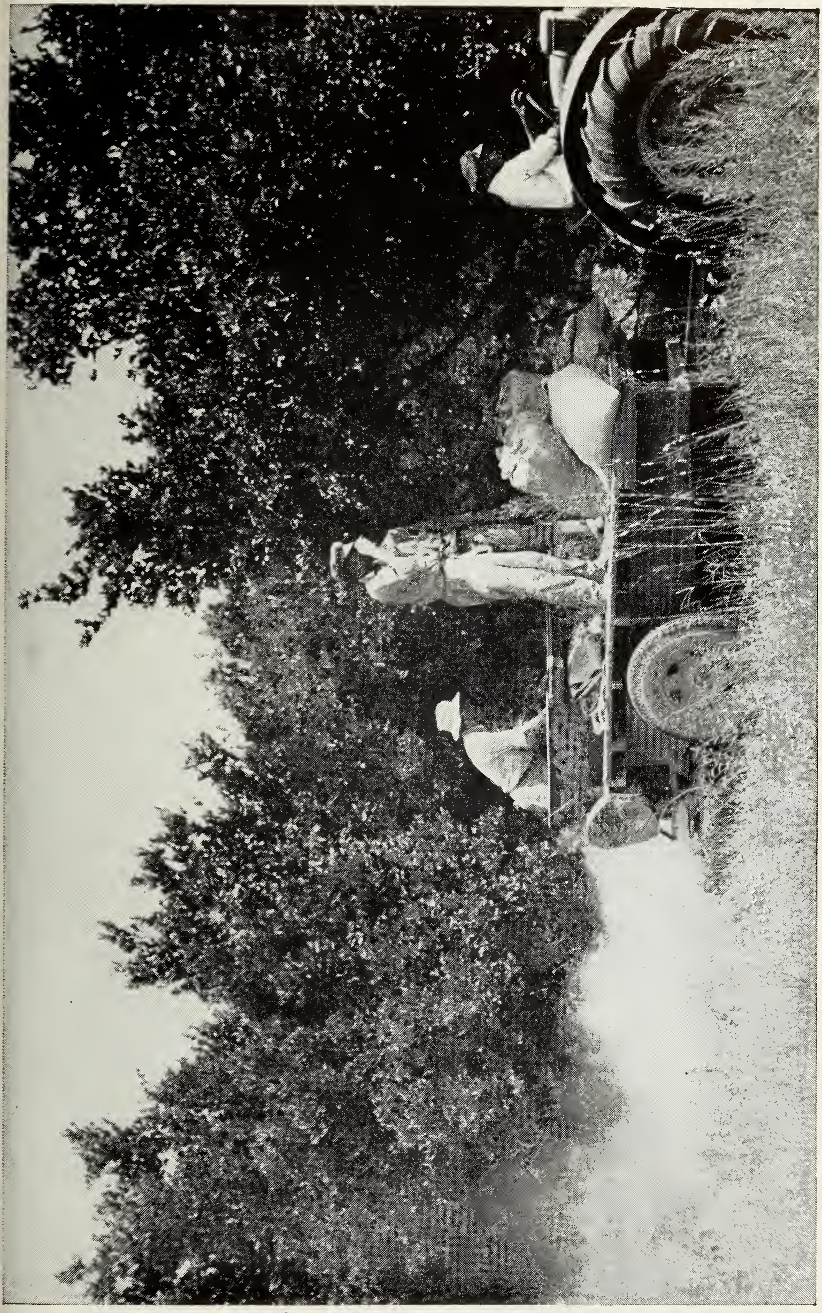


Fig. 42.—Fertilizer spreader in operation. The two laborers who are standing, dump sacks of fertilizer into the hopper and the operator on the step at the back operates the feed mechanism.

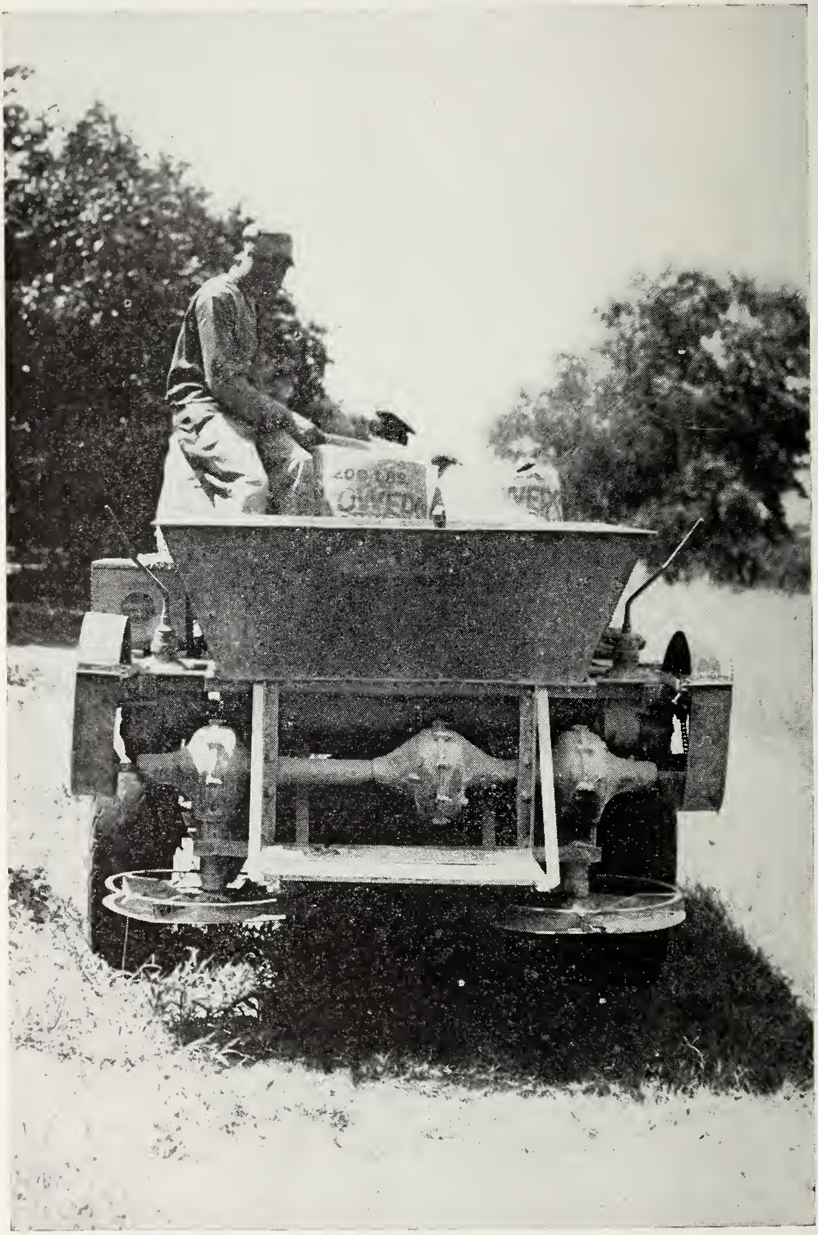


Fig. 43.—Rear view of fertilizer distributor. Fertilizer is mechanically fed from the hopper to the spinning discs below the step. Rate of feed is controlled by transmission levers on each side of hopper.

quired. Dolomite filler is not commonly used in modern fertilizers unless specified, so all dolomite must be applied separately.

Nutritional sprays of manganese, copper, zinc and molybdenum are widely used. When to use them has been discussed under the discussion of the individual elements. Details of materials and compatibilities will be found in the *Better Fruit Program* published each year by the Florida Citrus Commission.

Pruning

Relatively little pruning is done in citrus groves, there being no special type of pruning which corresponds to that used in commercial peach and apple production. Removal of dead wood is important because the fungi which cause melanose and stem-end rot grow in the dead wood, and spores are distributed from this wood to infect the growing leaves and fruit, as well as to the ripe fruit in which they may produce stem-end rot after harvest. Usually, groves are pruned once a year to remove dead wood fairly thoroughly, and the usual rules relative to making smooth cuts close to the branches that are left are followed. In such removal of dead wood, pruning paints are seldom used unless the cuts are very large and into live wood. The time of pruning is not particularly important, and it is usually done during the summer when labor is most plentiful. This type of work should be avoided when the trees are in growth or blooming as the new growth is very tender, and the necessary climbing in the tree may result in considerable breakage of new shoots. With the above exception, the dead wood may be removed at any time of the year that labor is available. This kind of pruning is commonly done on a piece-work basis, and men employed as pickers during the winter turn to pruning during the summer.

Other than pruning out the dead wood, it is desirable to remove low limbs which come close to or touch the ground. The reasons for this are several. Such low limbs bending down and touching the ground when full of fruit are a common pathway for infestations of mealybugs which come from cover crop plants and are also sources of scale infestations because they are close to the ground where they are hard to spray and are covered with dust from fertilization and cultivation. It has been a common practice in the past to leave trees headed very low with many of the limbs touching the ground when the fruit was sized up. This was fairly satisfactory as long as hand-spreading of the fertilizer was resorted to and the soil under the trees was stirred once or twice a year by hoeing. Under modern conditions, however, it has not been entirely satisfactory because the low-hanging limbs keep the fertilizer distributor from throwing fertilizer under the trees and also because hoeing has been rather generally abandoned in citrus groves, and the undisturbed soil under the trees becomes irreversibly dry or, as the grower commonly terms it, "greasy". As a result, the soil will not take water satisfactorily and during the rainy reason the water runs out from under the tree and the soil under the tree even during the rainy season remains dry. Where hand work is generally abandoned in a grove and dependence is placed on fertilizer spreaders and cultivation implements, the trees should be pruned up so that the spreader can throw fertilizer under the tree and the cultivation implements can be offset and used to stir the soil under the tree.

When low-hanging large limbs are removed, the cuts should be carefully made so that they will be smooth and the bark untorn; and the cut surface should be covered with a good pruning paint after the cut is made. These paints should not contain penetrating solvents because these may kill the exposed cambium and prevent callousing. In groves where practically all fertilization and cultivation is done by mechanical means, these low-hanging limbs should be removed at regular intervals of 2 or 3 years and the trees pruned up rather high if the best results are to be obtained.

Watersprouts that occur on the trunk and main limbs should be removed whenever they appear, mainly because these are excellent places for scales and whiteflies to become established and spread to other parts of the tree. In properly pruned groves the tree will have a heavy

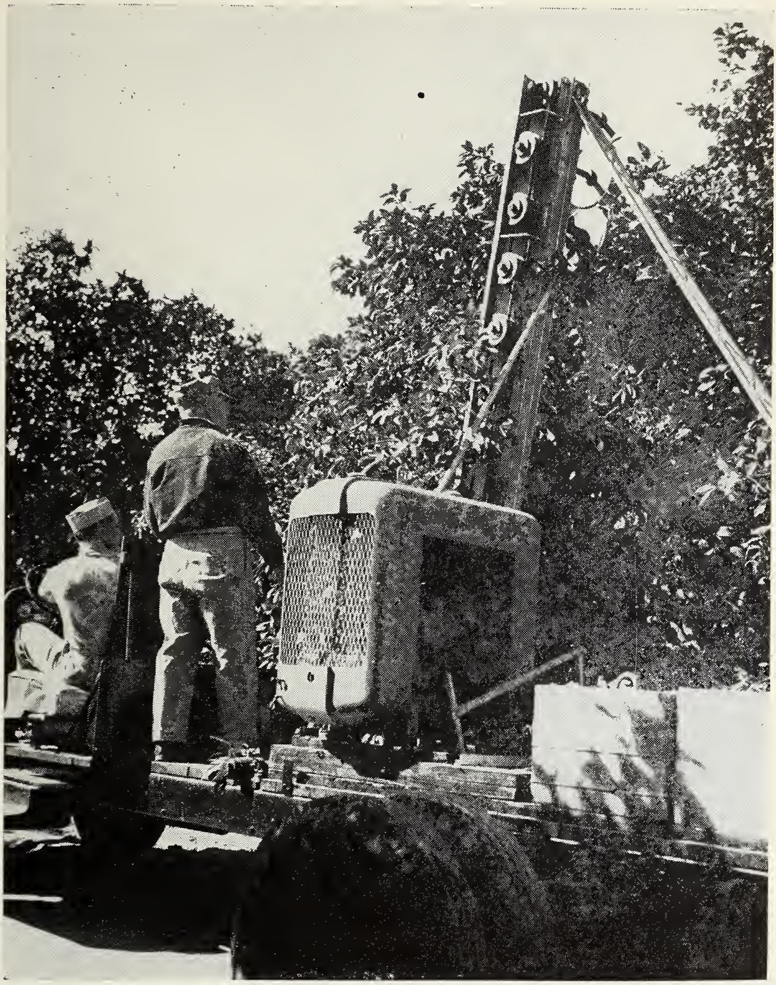


Fig. 44.—Hedger making vertical cut on side of large tree. Hedger is driven slowly down the row.

canopy of outside leaves but the inside limbs will be free of growth and dead wood.

In recent years, mechanical sprayers such as the Speed Sprayer have been increasingly used and difficulty has been experienced in older groves which are beginning to overlap. As a result, the practice of hedging the trees either by hand or mechanically has become common practice. The sides of the trees next to the middles in which sprayers are to be used are hedged vertically to leave an alley-way 6 or 8 feet wide and the trimming is repeated at about 3-year intervals. This practice makes grove work much simpler and the mechanical hedger developed by the Citrus Experiment Station is now widely used.*

Disease and Insects

No attempt will be made here to go into detail on control measures used in Florida for insects and diseases, since these practices change from year to year as new insecticides and fungicides are developed. A spray and dust schedule called the "Better Fruit Program" is published each year by the Florida Citrus Commission, Lakeland, Florida, and is available to all citrus growers on request. In it will be found the latest recommendations of the research agencies for the control of insects and diseases. A brief review of the principal diseases and insects is given below:

MELANOSE: This disease is caused by a fungus, *Phomopsis citri* Faw., which grows in the dead wood and produces spores which are distributed in rain and dew. The young leaves and fruit are susceptible to infection and this infection results in the formation of brown corky areas, which, when numerous, give a sandpapery effect to the peel of the fruit and the surface of the leaves. When infection is severe, it may result in the shedding of young leaves and fruit as well as disfiguration of the fruit when ripe. The same fungus causes stem-end rot of the fruit in transit. All varieties of citrus are susceptible to melanose attack.[1]

LEMON SCAB: This disease is caused by a fungus, *Sphaceloma fawcetti* Jenkins, which attacks young leaves and fruit. It causes raised areas which are light brown on top and which may severely injure the leaf and prevent its functioning properly, or when occurring on the fruit, lower the grade. Oranges are not affected by lemon scab, and sweet orange scab is not known to occur in Florida. Grapefruit, tangerines and Temples, as well as lemons, are severely attacked in some although not all citrus growing areas in the state. On grapefruit it is more acute in the coastal sections of the state, and control measures are more commonly practiced in such areas than in the interior citrus growing areas.[1]

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*For details concerning the construction of the hedger see Bul. 519 of the Florida Agricultural Experiment Station, Hedging Machine for Citrus Groves, by D. S. Prosser, Jr.

[1] For further information on melanose, see: Ruehle, Geo. D. and Wm. A. Kuntz. Melanose of Citrus and Its Commercial Control. Fla. Agr. Exp. Sta. Bul. 349, 1940.

TRISTEZA OR QUICK DECLINE: This is an insect borne virus disease which infects oranges, grapefruit and tangerines. When the infected trees are budded on sour orange stock or grapefruit stock, death of the tree eventually occurs. The tree may die quickly, in the space of a month, or may become stunted and live on in this condition for several years. Stocks such as sweet orange, rough lemon and Cleopatra mandarin are considered to be tolerant to the disease since trees budded on these stocks continue to grow and produce fruit though they may have some symptoms which render them less valuable than uninfected trees. This is especially true of grapefruit.

Tristeza has done great damage to the citrus industries in Argentina, Uruguay and Brazil and also California. It has recently been discovered in Florida, but appears to be less virulent than it is in South America.*

SPREADING DECLINE: The cause of this trouble has recently been identified by workers at the Citrus Experiment Station as the burrowing nematode, *Radopholus similis* (Cobb) Thorne. This nematode burrows into and kills the feeder roots and may be active down to 12 feet or more. An affected spot starts as a single tree and spreads at the rate of 1 to 2 trees per year. The trees do not die, if cared for, but are thin of foliage and produce only small crops of small fruit. This is probably a reflection of the fact that they have only a sparse

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[1] For further information on scab, see: Ruehle, Geo. D. and W. L. Thompson. Commercial Control of Citrus Scab in Florida. Fla. Exp. Sta. Bul. 337, 1939.

*For more detail see Bulletin 2 of the State Plant Board of Florida. Tristeza Information for Florida Citrus Growers, by A. F. Camp, E. P. DuCharme and L. C. Knorr. April, 1953.

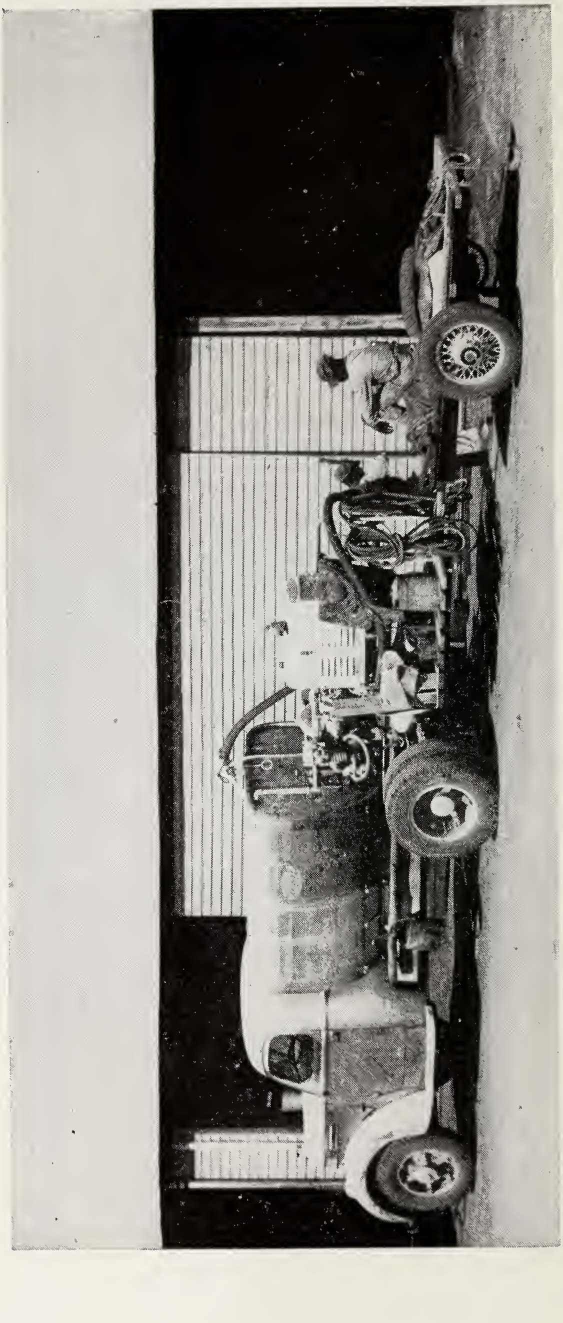

Fig. 45.—Truck sprayer with trailer for hauling supplies from grove to grove. The tank has a capacity of 600 gallons, the pump 35 g.p.m., motor 20 h.p.

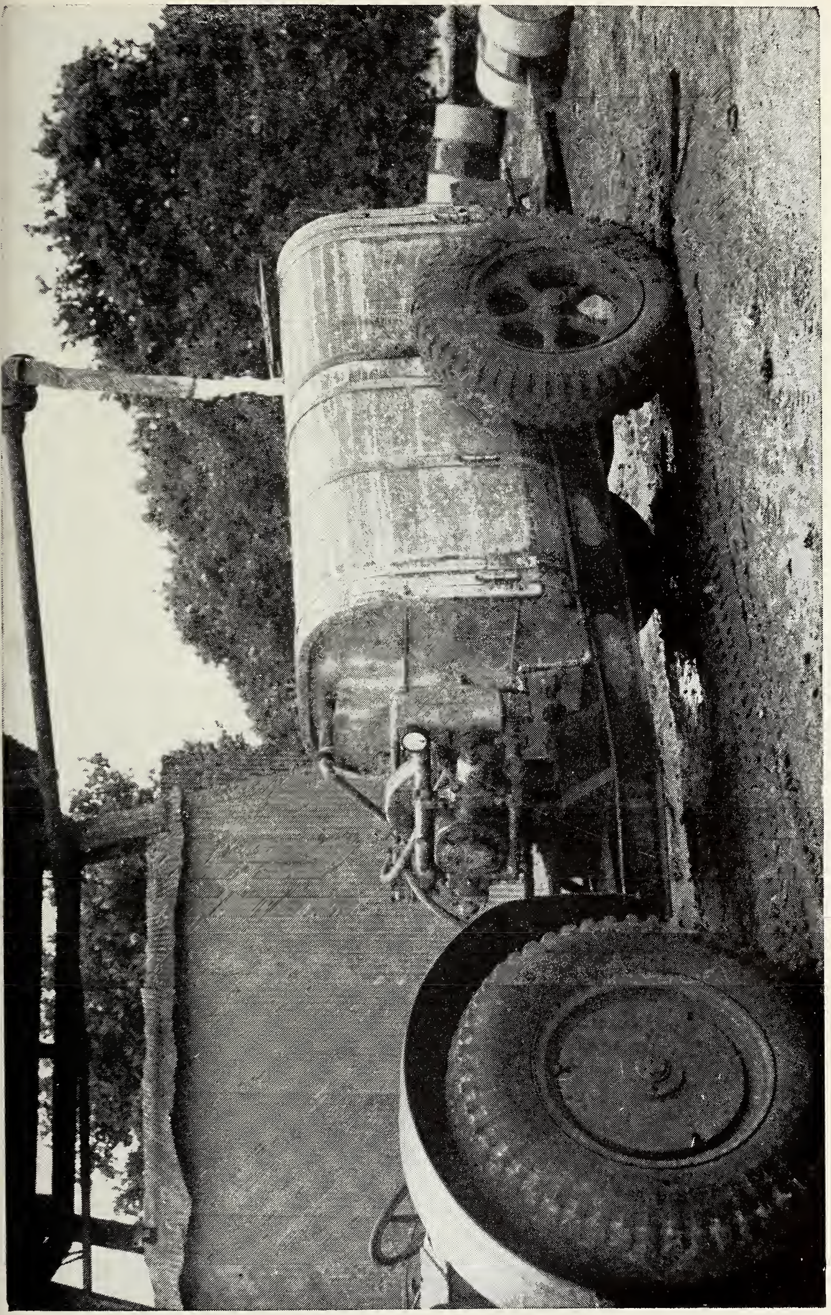

Fig. 46.—Tractor sprayer with 600 gallon tank and 35 g.p.m. pump, driven by power takeoff from tractor motor.

feeder root system, most of it in the topsoil. All standard rootstocks are affected. Most of the trouble is in Polk and Highlands Counties, with some areas in other counties having light sandy soils.

RUST MITES: These are very small mites which can only be seen by most people by means of a hand lens. They are present in groves throughout the year, causing a smooth brown marking on the fruit which is probably due to the release of essential oil from the injured oil glands and consequent burning of the surface of the fruit by the peel oil. These mites are readily controlled by means of sulfur, and most growers attempt to keep sulfur on the trees throughout the period when fruit is present on the trees. This is accomplished by using rather liberal applications of sulfur in sprays or by using sulfur dusts. The mites are not confined to the fruit but multiply on the leaves as well, and this fact is often overlooked by growers.

PURPLE MITES: Purple mites are known in other areas, and frequently in Florida, as "Red Spiders." They have been of increasing importance in Florida in recent years and have caused considerable damage when severe infestations have coincided with extremely dry weather. Under such conditions, they may cause collapse of the leaf tissue, termed "mesophyll collapse," and consequent heavy loss of foliage. If this occurs in the fall, the wood on which the foliage was killed may die.

SIX-SPOTTED MITES: These mites attack the undersurfaces of the leaves, usually during the spring. They cause irregular yellow spots which become slightly raised above the rest of the upper leaf surface and which have a fine brownish web on the under side which is visible to the naked eye. These mites are serious in only occasional years.

PURPLE SCALES[1]: Purple scale, *Lepidosaphes beckii* (Newm.), is the commonest scale insect in Florida

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[1] For more detailed information concerning scales, see Bul. No. 462, Purple Scale and Fla. Red Scale as Insect Pests of Citrus in Fla., W. L. Thompson and J. T. Griffiths, Jr., September 1949; Circular S-5, Identification of Fla. Red and Purple Scales on Citrus Trees in Fla., J. T. Griffiths, Jr., and W. L. Thompson. Both from Agricultural Experiment Station.

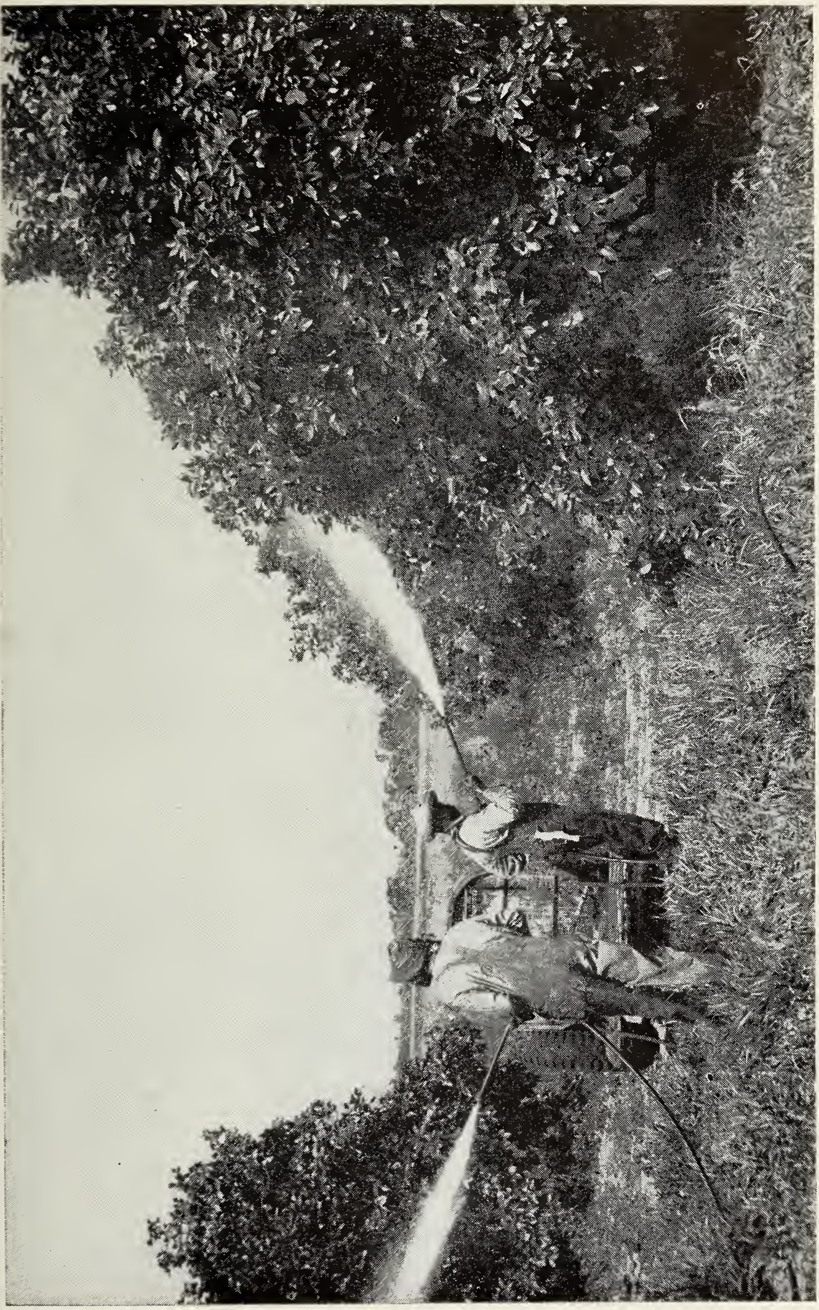

Fig. 47.—Spraying with tractor-drawn outfit.

citrus groves. It is a rather long, comma-shaped scale, pointed at one end and rounded at the other and of a brownish purple color. They occur on both leaves and fruit and can become so numerous as to cause shedding of leaves and fruit. Their development is encouraged by succulent foliage and shade and also inert spray residues and dust on the leaves. They can multiply so rapidly

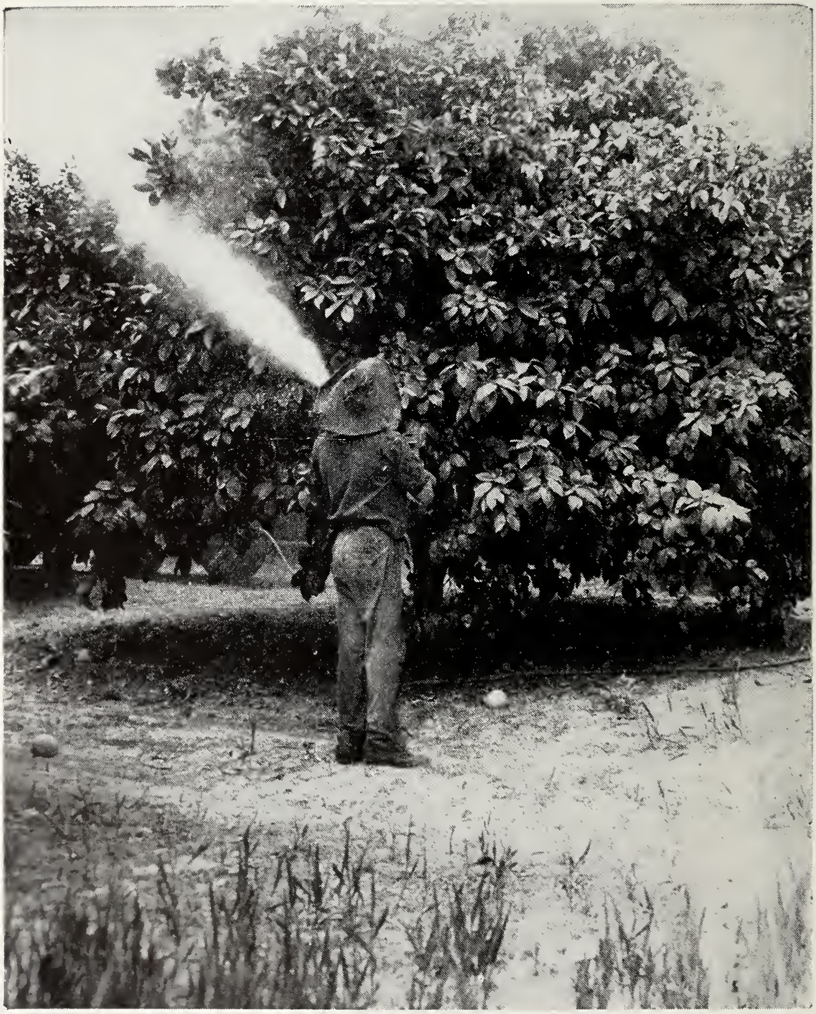

Fig. 48.—Spraying with oil. A high pressure with a large disc in the gun is used to turn over the leaves so they will be wet on both sides.

during the summer that control measures should be applied before they become numerous.

Florida Red Scales: Florida red scales, *Chrysomphalus aonidum* (L), are round scales of a reddish color, with a raised purple dot in the center. They were formerly most common along the coast but in recent years have become increasingly numerous in the central part of the state. Florida red scales can build up very rapidly in late summer and do a great deal of damage if not controlled. The eggs are protected under the mother scale and may not be killed by the application of a scalicide unless it is properly timed.

Whiteflies: The adult whitefly looks like a small white fly but is not a true fly. It lays its eggs on the young citrus leaf and these hatch into larvae which do most of the damage by sucking sap from the leaf. It is common during the spring and early summer. The larvae or nymphs excrete a considerable amount of honeydew and the black sooty mold fungus grows in this to form a black coating on the leaf during the summer. This is the evidence of the whitefly most commonly noted by growers. The whitefly prefers succulent foliage and will frequently start in a grove on the succulent water sprouts in the center of the trees. The larvae prefer shade and usually attach themselves to the undersides of the leaves.

Miscellaneous Insects: Mealybugs, aphids, plant bugs, grasshoppers and other insects cause damage occasionally.

The above discussion of major insects and diseases is given in order to explain to some degree the sort of spray and dust applications that are used in Florida in which several materials may be combined for controlling several pests. A spray schedule prepared by the technical men of the State Experiment Station and the U. S. Department of Agriculture together with other agencies in the state is published by the Florida Citrus Commission each January, and a grower may obtain a copy from that agency in Lakeland, Florida, or from his County Agent. In order to give the grower a fair idea as to the sort of spray program needed, it will be outlined below, but may be out of date when this bulletin is received, so, for actual use, it is suggested that the reader obtain a copy of the current spray schedule from the Citrus Commission, the County Agent or insecticide salesman.

The best spray program consists essentially of the following:

(1) A dormant spray applied sometime during the latter part of January, containing zinc sulfate for nutritional purposes, a miticide, and wettable sulfur to kill rust mites, purple mites and six-spotted mites. When grapefruit or other scab-susceptible varieties are being grown in areas where scab is severe, copper may be included in this spray.

(2) A spray following fruit setting containing copper to coat the young fruit and protect against melanose, wettable sulfur to kill rust mites and a miticide to kill purple mites or six-spotted mites if they are present.

(3) A scalicide application sometime in June, July or August.

(4) When rust mites begin to develop at the end of the summer, either sulfur dust or wettable sulfur spray is applied to reduce them.

(5) A watch is kept in the grove during the winter and if rust mites develop, wettable sulfur or lime-sulfur plus wettable sulfur is used to control them. If purple mites are present, they can be controlled by adding a miticide to the wettable sulfur spray.

It will be seen that the average grove usually receives four applications of spray or dust and may receive a fifth when late varieties need to be protected. This discussion is only very general and a detailed discussion of the immediate problems in hand should be obtained by consulting the Spray Schedule mentioned above.

Pest control is extremely important to the grower selling fruit to the fresh fruit market, because failure to properly control various common insects and diseases may ruin the value of the crop. The effects which they

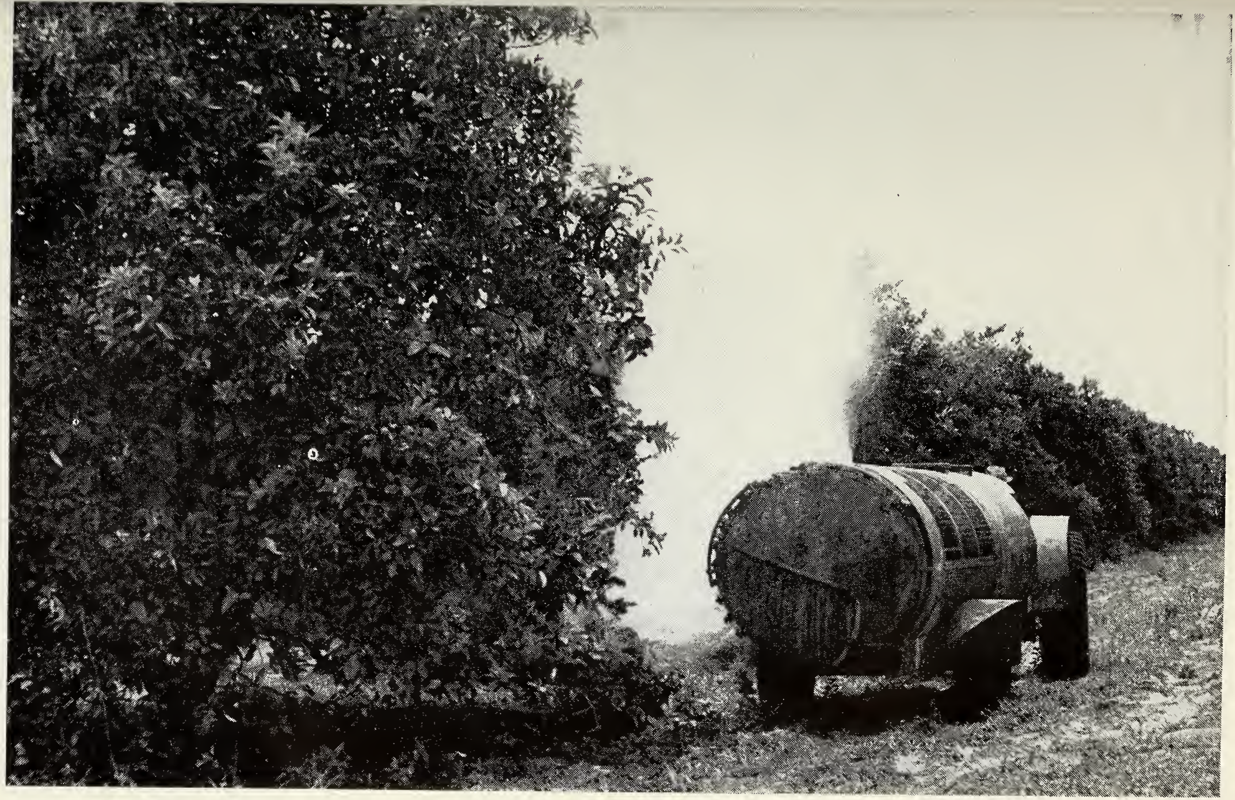

Fig. 49.—Shortage of labor has encouraged the development of mechanical spray devices. This one uses an airplane propeller to create a blast of air to carry the spray. One man operates this instead of the usual three for standard equipment.

may have are many, of which the most important from the grower's standpoint are reduced crop, lowered grades, and increased sensitivity of the tree to both cold and drought. It is wise for the grower to adopt a thoroughgoing spray and dust schedule and stick to it very closely, as otherwise some of the diseases and insects may result in the loss of a crop upon which a great deal of expense has been incurred. The grower should learn to identify at least the common insects and diseases accurately. He should also familiarize himself with the literature on insects and diseases, but most of all should follow a carefully laid out program to prevent their development rather than attempt to control them after they have become acute. In pest control, as well as in many other things, prevention is much easier than control, and this general policy is now followed by practically all growers.

In recent years, a great deal of fruit has been produced which has been earmarked for the processing plant from bloom. Surface disfigurations are not important on such fruit and modified spray programs which are intended to only maintain the tree and production have been developed. Such a program will be found in the *Better Fruit Program* along with the program for fresh fruit.

Irrigation

For many years irrigation was practiced only in a small way in citrus groves in Florida, and most of the irrigation was in the areas where artesion water was available. In recent years, and particularly since the extensive plantings on light sandy soils have come into production and the trees have become sufficiently large to demand a great amount of moisture, irrigation has been on the increase. Rainfall in Florida, if evenly distributed, would be sufficient to take care of the water requirements of citrus groves, but unfortunately it is rather irregular with the heaviest rainfall coming during the summer rainy season, and particularly during June and July. The fall months of September, October and November are frequently very dry and a similar condition quite commonly occurs during the spring period from February into May. During these periods of drought the trees may be so short of water as to go into a heavy wilt and lose a crop that is already set on them or fail to set a crop at the time of blooming.

Relatively little irrigation is carried on in which a regular supply of water is systematically applied to the trees to make up for deficiencies in rainfall, but irrigation is done during dry periods in groves that are just about to go into a wilt or which have already started to wilt.

Whether systematic irrigation would be highly profitable has never been definitely established, but the use of irrigation in critical periods is definitely valuable. Extremely dry weather in the fall may produce a heavy shedding of fruit and leaves and result not only in the loss of crop but also in loss of cold resistance. Drought during the spring may prevent the setting of a crop or

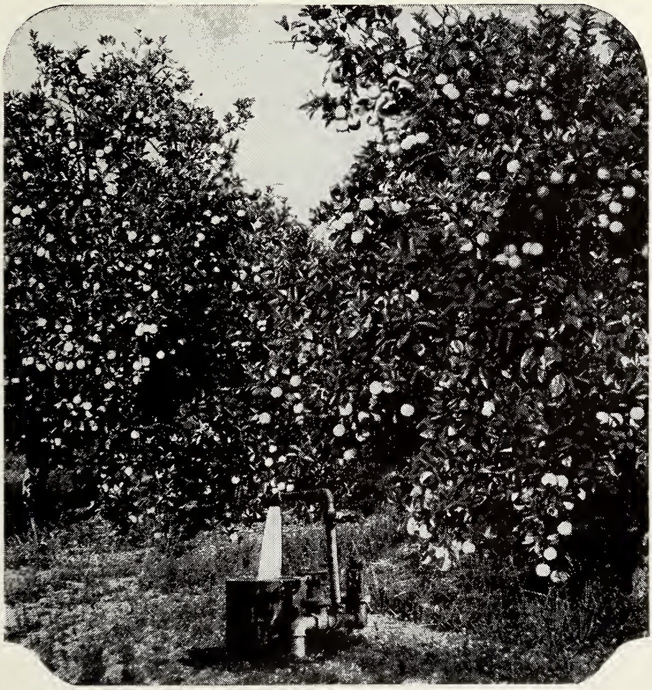

Fig. 50.—Artesian water is available in some coastal areas and a few interior districts.

may result in the shedding of young fruit. Whenever possible it is advisable to have irrigation available at least for these critical periods and, if possible, to use it before the trees wilt. In general the application of about 2 to 3 acre-inches of water at one application is about all that can be profitably applied. This is particularly true on the light sandy soils since additional water will only result in leaching. Heavier soils can use more water at a single application, but it is not common to apply much more than this.

Methods of Application

A great many methods for the application of irrigation water have been attempted in this state, most of them copied from methods used in other states; but in recent years methods have been developed which have been better adapted to conditions here and seem to be fairly satisfactory. These methods, however, vary with the local conditions, involving both water supply and type of soil as well as type of planting.

Artesian Areas: Most of the areas where artesian water is available are along the coast. Groves in these areas are commonly planted on ridges or "beds," each ridge carrying a single row and the tops of the ridges being from 10 to 30 inches above the bottoms of the middles. The water from artisian wells is run into the middles until they are nearly filled. The water is held in the middles between the ridges for two or three days and then released. This method has not proved to be entirely satisfactory. In the first place, in some of the older artesian areas the water has become too salty for irrigation purposes, and good water is available only in limited quantities, whereas this method of irrigation presupposes an almost unlimited supply of water. The second disadvantage is that many soils in these locations are only slightly pervious to water when extremely dry. The result is that while the middle may stay full of water for two or three days, there is little lateral penetration into the ridges, and trees continue to wilt. In slightly more pervious soils this method has proved fairly satisfactory, but is still wasteful of water and would be impractical if artesian water ran short.

In some of the old artesian areas, it is not uncommon to find well water containing from 500 to 1500 p.p.m. salt and in some few areas well water containing from 2000 to 5000 p.p.m. of salt may be found. The exact concentration at which water becomes toxic due to excess salt depends upon several factors. One of the main factors is the amount of organic material in the soil; the larger the percentage of organic matter, the more salt, that can be tolerated in the irrigation water. Also, the number of irrigations necessary between periods of leaching rain is important; that is, one application of water followed by leaching rains a few weeks later might cause no damage, while two or three successive irrigations without intervening rains would cause very severe damage. Any grower using artesian water or pumping water from strata that are likely to be salty if extensive pumping is carried on, should watch the salt content of his irrigation water very closely. Usually water containing up to 1000 p.p.m. salt is relatively safe, providing leaching rains occur occasionally and for single irrigations water with as much as 1500 p.p.m. can be used on many soils. Above 2000 p.p.m. the water is likely to be quite dangerous on almost any soil, and if more than one irrigation is required between rains may cause extensive loss of roots.

INTERIOR AREAS: In the central part of the state it is customary to obtain irrigation water either from lakes or deep wells, using centrifugal or turbine pumps and gasoline or distillate burning motors, although some electrical installations are used. The water is brought to the grove by means of a permanent main laid under the ground, which is usually made of steel pipes welded together and coated inside and out with a bituminous coating, or of cement-asbestos pipe. Screw-joint pipe or cast iron pipe is very little used for this purpose. Concrete pipe has not proved satisfactory owing to the pressures that are commonly maintained on such lines.

Where a permanent main is not desirable or where the same pipe is to be used to irrigate a number of different groves, portable main is used. This consists of the so-called lock-joint pipe in which the joints are about 16 feet in length and provided with a quick-locking joint with a rubber gasket which expands under water pressure. This pipe was formerly made of galvanized iron but now is usually aluminum. These mains may be laid for long distances and operate satisfactorily if they are of the proper diameter.

Water is distributed in the grove by means of slip-joint pipe or lock-joint pipe. In some groves the old practice of flooding the land by manipulating the pipe line is still used, usually by laying the line the full length of the row and using ells (L's) to throw the water under the trees as the line is shortened. This method is rather wasteful of water and also is not very efficient because the very dry soil under the trees sheds the water out to the middles and, in the short period of irrigation, it does not penetrate to the root system; also on slopes, a great deal of washing results from this method of application.

Sprinkling replaced flooding during the '30's, using galvanized iron pipe perforated to produce a V-shaped spray covering a 25-foot middle or inserted sprinkler valves. Originally the pipes fitted together with a metal-to-metal contact, but that was replaced with a self-sealing joint using a rubber gasket. Aluminum pipe has now replaced the galvanized iron and improved quick-locking connectors are used. Since the pipe must be transferred from one middle to another, aluminum pipe has a great advantage because of its lightness. Joints are 16 to 22 feet in length and perforated with two rows of drilled holes to produce a V-shaped pattern which will cover a 25-foot middle. Methods of perforating vary but a common pattern places the perforations at varying distances from the center line in order to improve the coverage. Six-inch pipe is now commonly used for the sprinkler lines.

The time required for applying the water to a middle can be calculated readily from the area involved and the gallons per minute being applied. The following fundamental information is all that is required:

1 acre = 43,560 sq. ft.

1 acre-inch of water = 27,000 gals. (approx.).

Length of line being used.

Width of middle.

Delivery of pump in gallons per minute. (Obtained from manufacturer or engineer).

For example, it is common to use sprinkler pipe in 660-foot lines. Where rows are 25-feet apart, 25 x 660 equals approximately 16,500 sq. ft., or about three-eighths of an acre; ⅜ x 27,000 gallons or approximately 10,000 gallons would be equivalent to one acre-inch on this area. If two acre-inches are to be applied and the pump is delivering 1,000 gallons per minute, it would require 20 minutes (10 minutes per acre-inch) to put on the two inches of water.

It is customary to have at least two lines available, one of which is being laid while the other is in operation. The time required for application is also important, and where the soil is difficult to wet, it is frequently desirable to have two lines operating at once while a third is being laid. In this way only one-half as much water is put through a given line in a specific length of time, and in the case mentioned above it would require 40 minutes to the middle to apply two acre-inches of water rather than 20 minutes. This gives more time for downward penetration in the very dry soil under the tree and does a more satisfactory job.

Furrow or check irrigation such as is commonly practiced in California is impractical on most soils in Florida because of the very rapid downward penetration of water. Under California conditions the slow downward penetration makes possible a very good lateral distribution of water from furrows, while under Florida conditions, and particularly on the light sandy soils, the water moves downward so rapidly that little or no lateral movement takes place. On a few Florida soils it is possible to use furrow irrigation, providing the land has

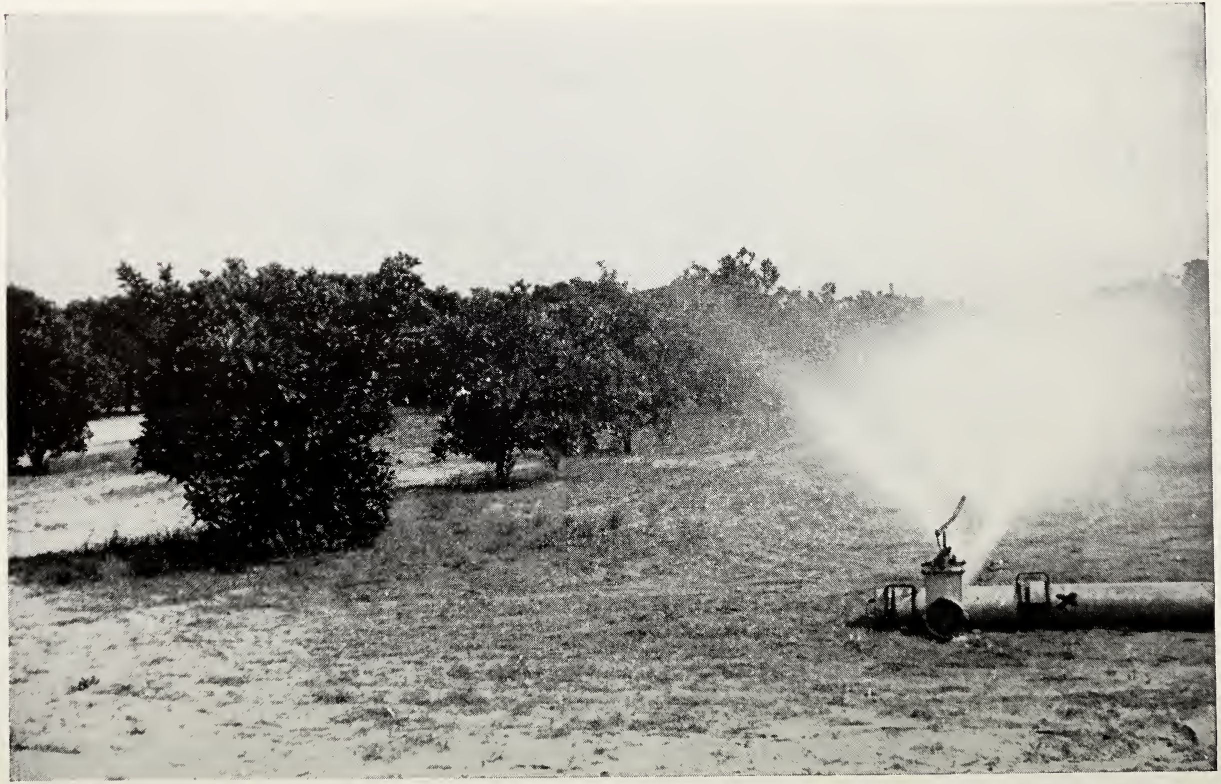

Fig. 51.—Portable sprinkler pipe in operation in a young grove.

been properly graded before the trees were planted, but such groves are uncommon, and on most of the sandy soils some form of distributing pipe must be used.

No attempt will be made in this bulletin to discuss in detail all of the problems involved in the engineering side of irrigation, but certain fundamental things should be kept in mind and an engineer consulted when the installation of an irrigation plant is considered. The following are the causes of a great many difficulties and should be avoided: Do not install a system to use water from a very small lake, pond or swamp where the water carries a great deal of trash. Such water supplies are likely to be dry or nearly dry when water is needed worst, and trash in the water will stop up the perforations in the pipe. Where the water supply is uncertain it is better to have a well drilled. The time when water is most needed is during droughts of long duration and an irrigation plant installed to draw water from a pond or swamp may find itself without a water supply when water is most needed.

Pumps vary considerably in construction, depending upon the purpose for which they are to be used. Since growers are not usually familiar with the various types of pumps it is best to consult an engineer before purchasing. Rebuilt automobile engines have been extensively used for pump operation in the past, but their use has been decreasing for several years. These engines are not built for continuous service under heavy loads and are less satisfactory than the industrial type of engine if a large amount of irrigation is to be carried on. Modifications of automobile motors to use distillate or tractor fuel also are not entirely satisfactory and may result in extensive engine trouble. It is usually preferable to purchase a standard industrial engine built for the purpose of delivering power for long periods under full load. Diesel engines are widely used for this purpose. Electricity provides the cleanest, most convenient source of power, but is usually more expensive.

Mains should be sufficiently large to carry the required amount of water with a minimum loss of head due to friction. One of the most common mistakes is using mains that are too small. The smaller the main the more power required to push a given amount of water through it, and where long mains are involved it may account for a great loss in power. A competent authority on such matters should be consulted before purchasing a large installation as a relatively small initial saving through using a small main may result in excessive pumping cost throughout the life of the installation. It should be remembered at all times that the higher the head against which the water must be pumped, the smaller the amount of water delivered per gallon of fuel. The operating head is made up of the elevation between the point of water intake and the point at which it is delivered, plus the friction in the main plus the pressure required for the distribution pipe. In good installations, the loss of head due to friction should be a relatively small item, but in too many cases it makes up the bulk of the head at which the pump operates. It should be remembered in permanent installations that the loss of head when the pipe is new is smaller than the loss when the pipe gets old and scaly inside, and the size of the main should be selected so that the head loss will not be excessive after 10 or 12 years of use.

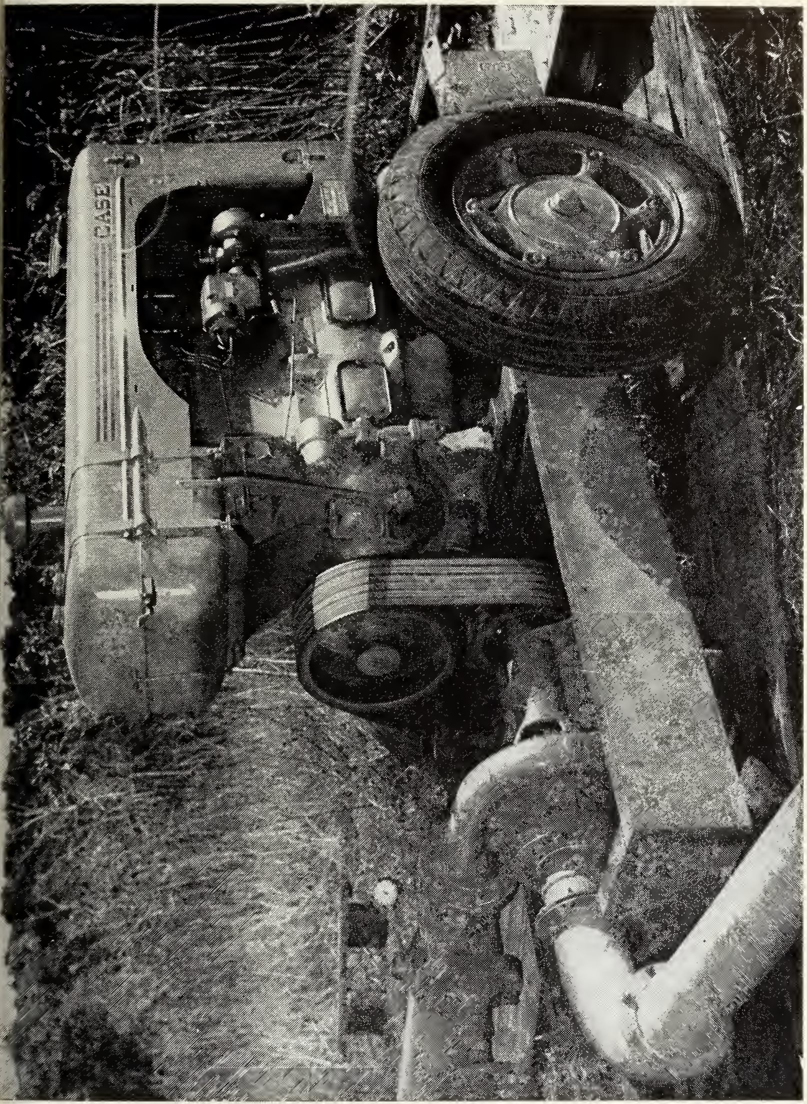

Fig. 52.—Portable irrigation outfit set up to draw water from a lake.

Cold Protection

The first consideration in the problem of cold protection is the selection of a warm location and this has already been discussed in detail. This matter is of extreme importance for the characteristics of the location can not be changed, and a location that is chronically cold is likewise chronically unsatisfactory due to persistent damage to both fruit and trees. Sometimes when a grove is very young and the location is found to be extremely cold, it is better to move to a new location than to attempt to employ artificial means of cold protection in order to obtain production. In any case artificial protection in Florida is seldom considered a routine procedure but rather a safeguard against unusual conditions.

The second great factor in cold protection is proper fertilizing and spraying, which has likewise been discussed in the section on fertilization. It has been shown conclusively that deficient trees are more susceptible to cold damage to the extent that a cold wave may result in a complete loss of crop and even loss of limbs up to two or three inches in diameter in deficient trees while adjoining trees that are properly fertilized and sprayed are unhurt. It has been shown that a deficiency of any of the common elements will increase the cold sensitivity of the trees, and extreme deficiencies will make the trees so susceptible to cold injury that even in a moderately warm location the grove will be unprofitable.

All of the Florida citrus area is subject to occasional ~~frosts,~~ and damaging temperature may occur during many winters. To ~~insure~~ against severe colds, many ~~growers use some kind of artificial cold~~ protection or ~~grove heating. The general~~ principle of grove heating reduced to its ~~simplest terms~~ consists of heating the air in the grove by burning fuel; but a few notes on the underlying principles may be helpful. Freezes in Florida originate in the Arctic and move down through Western Canada and thence through the states east of the Rocky Mountains. These storms or cold waves are characterized by high barometric pressure and carry with them into the state a considerable amount of cold, dry air, with the result that humidity is greatly lowered as well as the temperature. Within the state, the advancing cold wave usually is preceded at its leading edge by rain, followed by cold, dry northwest winds. This cold dry air offers little resistance to radiant heat which is lost from the soil to the upper atmosphere, thus cooling the soil rapidly at night. The chilled soil in turn cools the layer of air next to it. On quiet nights the air close to the ground is much cooler than the air higher up, and this cold air, also being heavier than warm air, drains from the higher to the lower levels. This results in frost pockets in the lower places from which the air can not drain. The phenomenon of lower temperatures close to the ground and warmer temperatures higher up is known as "temperature inversion" (see Fig. 53). The extent of inversion depends to a considerable extent upon the air being relatively still plus favorable conditions for radiation, i.e., dry and dust-free air. On windy nights the air structure is broken up, and occasional puffs of wind will cause the surface temperature to rise by mixing

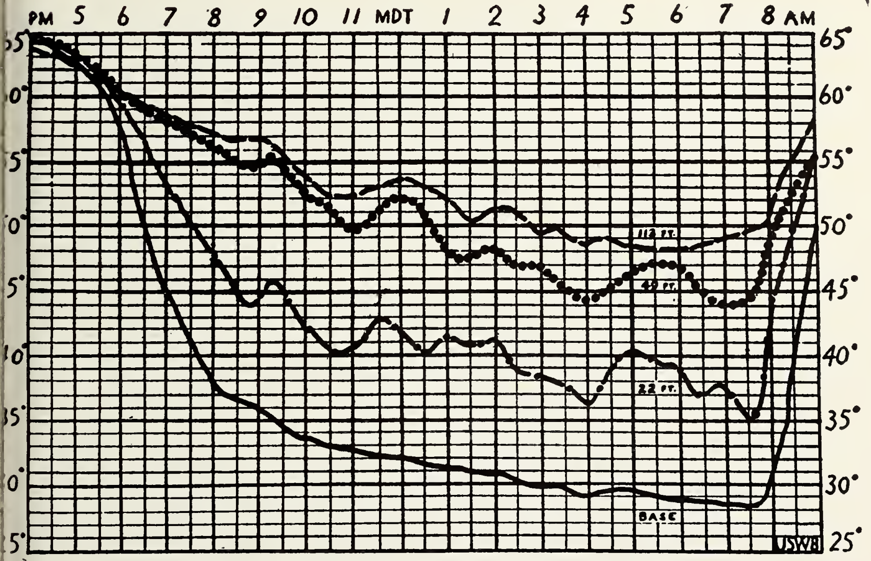

Fig. 53.—Continuous records of temperature taken at stations located on tower at Citrus Experiment Station at Lake Alfred, on February 5-6, 1937. Note how much warmer it was on this night a short distance above the ground than it was at the base station in the grove. (From Frost Service Grower's Handbook, 1937-38. Compiled by Federal-State Horticultural Protection Service.)

warm air from the upper layer with the colder lower layer. In severe freezes, the first night is usually quite windy, and there is relatively little inversion of temperature due to the constant mixing of the air. The second and third nights are usually quite still, with considerable temperature inversion.

The general principle of grove protection by artificial means is to heat the air, and that is usually quite easy if the air is still. On windy nights, however, the heated air is carried away rapidly and heating becomes correspondingly difficult.

In trying to avoid the vexatious problems of firing, various attempts have been made to protect groves in other ways. Some of these methods have attempted to take advantage of temperature inversion and by means of fans to mix up cold air next to the ground with the warm air higher up. These have been generally unsatisfactory and will fail entirely on very windy nights when there is little or no temperature inversion. Water sprays have also been used to some extent, but the amount of heat released by the cooling or freezing of water is relatively small, and the weight of the ice on the trees is likely to result in breaking of the limbs and extensive injury on very cold nights. After a great many years of extensive protection work in the United States, the use of fires for heating the air is still the standard procedure, and the only one that can be generally recommended.

The fuel to be used in firing depends on local conditions. In California, oil is almost universally used because oil is cheap and readily available. In Florida, wood has been very much cheaper than oil, coke or coal, and while it requires more labor to fire with wood, this has not been a drawback in the past but may be in the future. The value of the fuel is determined by the relative cost of producing a given amount of heat. Heat measurements are commonly in terms of the British thermal unit (BTU), which is the amount of heat required to raise one pound of water one degree F. The burning of one pound of oil will give about 19,000 to 20,000 BTU, and 2-½ pounds of wood will give about the same heat as one pound of oil, or measured in another way, one gallon of oil and 19 pounds of wood are roughly equivalent in heating value. It has been roughly calculated that at a price of about 5¢ per gallon for oil, wood would still be the cheaper fuel in Florida up to about $9.00 to $10.00 per cord. Wood in recent years has become increasingly scarce, and the wood obtained for grove heating today probably does not have the value indicated above. Increased difficulty in obtaining sufficient labor has also handicapped the expansion of grove heating, particularly with wood as a fuel. Satisfactory wood for heating must be the so-called "fat wood" or "light wood"; that is, wood that has become impregnated with rosin due to some injury to the pine tree. Unless the wood is very "fat," it will deteriorate with time and the investment in fuel will be lost. Oil and coke will keep well if properly stored and have a considerable advantage over wood in this regard. Another factor that has also encouraged the use of wood is that it can be burned in open fires and does not require an investment in pots or heaters, although some wood heaters have been sold.

Wood for grove heating is usually cut in 4-foot lengths, 5 or 6 inches in diameter, and 3 lengths are used to lay a fire. Two pieces are laid in a "V", with their ends together, the point of the "V" being to the south, and the open part to the north. The third stick of wood is then laid between the 2 first pieces with its end on top of the bottom of the "V" (Fig. 54). A few chips of fat pine are put under the top piece to act as kindling (Fig. 54). The number of such fires required per acre will vary with the location and the severity of the freeze, but it is customary to put at least one to every check or about 70 per acre in the average grove. A double row of fires is placed along the north and west sides of the grove. Also, fuel must be provided close to the point where the fires are laid so that a stick may be added as necessary on very cold nights. Additional supplies are piled outside of the grove or under the trees for quick distribution in a prolonged freeze.

When oil is used as fuel it must be burned in some sort of heater and these heaters, generally speaking, are

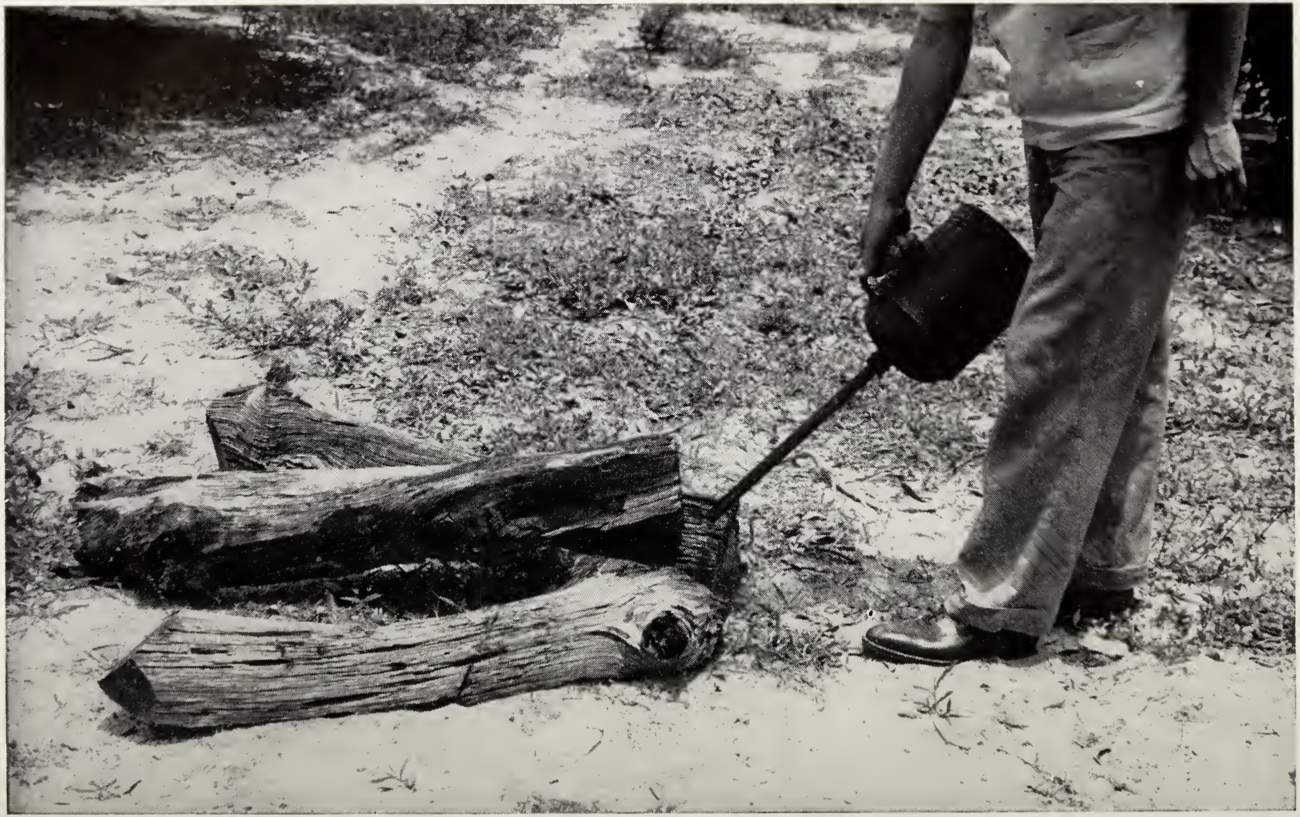

Fig. 54.—Wood laid ready for lighting. Kindling is at the juncture of the two lower pieces and under the top stick. The lighter is pointing

of two types. One is the tall stack heater, in which the fuel oil is changed to a gas by means of a pilot flame and the gas is burned in the stack with air admitted through the louvers near the base of the stack (Fig. 55). These heaters have a very high efficiency and make relatively little smoke. The other type of oil heater is the open type in which the oil is burned in a pot with an adjustable lid or in a slightly modified stack heater that is made to produce a so-called "lazy" flame. These heaters produce more smoke than the high stack heaters, but are cheaper to purchase, have less metal to deteriorate under humid Florida conditions, and are only a little less efficient. The standard heater has a bowl with a capacity of nine gallons of oil which will burn about twelve hours at the standard rate. Heaters with smaller bowls than this are not desirable because it may be necessary to refill them during the night, and all work that is not absolutely necessary at night, should be avoided because of the difficulties involved. Oil heaters are lighted with the same type of torch that is used for wood fires, and are readily lighted and extinguished so

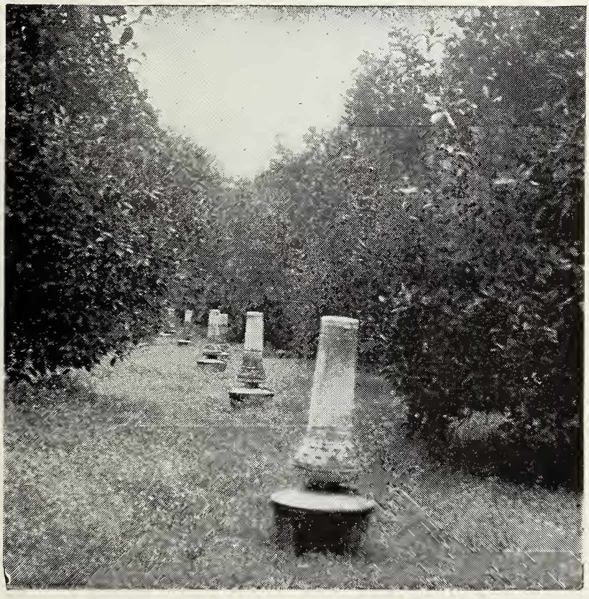

Fig. 55.—High stack oil heater. Note the louvers in the lower part of the stack. (Picture courtesy of Gulf Fertilizer Company.)

there is no waste of fuel through fires burning after the temperature rises above the danger point. About 50 to 70 oil heaters per acre are used, the number depending upon the coldness of the location.

Coke is used in specially designed heaters, but most of these heaters do not carry sufficient coke for an entire night and have to be replenished. Coke is relatively less used than either oil or wood in this state.

Regardless of what fuel is used, a supply should be on hand for at least three nights of heavy firing as severe freezes commonly last this long. Failure to have fuel on hand may result in the grove being protected the first one or two nights and unprotected the last night, which might mean that the value of the fruit was lost plus the money spent on heating during the first part of the cold period. Wood can be stacked in piles around the grove, but oil must be stored in tanks as delivery from dealers on short notice can not be depended upon. Coke likewise will have to have some provision made for storing, as it is not likely to be available for immediate delivery in sufficient quantities. If proper provision is not going to be made for additional fuel, then it is better not to make any of the investment. In the matter of wood it is best to provide enough to carry you through a very cold winter as wood can not be as readily replenished as either oil or coke.

Proper lighting torches should be purchased as homemade torches are likely to be very dangerous. Such lighters usually look like an overgrown oil can with a base holding about one gallon of fuel and a long spout having an asbestos wick at the top. The spout has a fine screen near the base which prevents the fire from flashing back to the bottom of the lighter (Fig. 56). Occasionally these screens become clogged and laborers cut them out and explosions occur. Lighters should always be carefully examined before use to make certain the screen is undamaged. Low-grade distillate is used in the oil heaters, but it is necessary to use something more volatile than this in the lighters. A mixture of equal parts of gasoline and distillate is commonly used. In operation

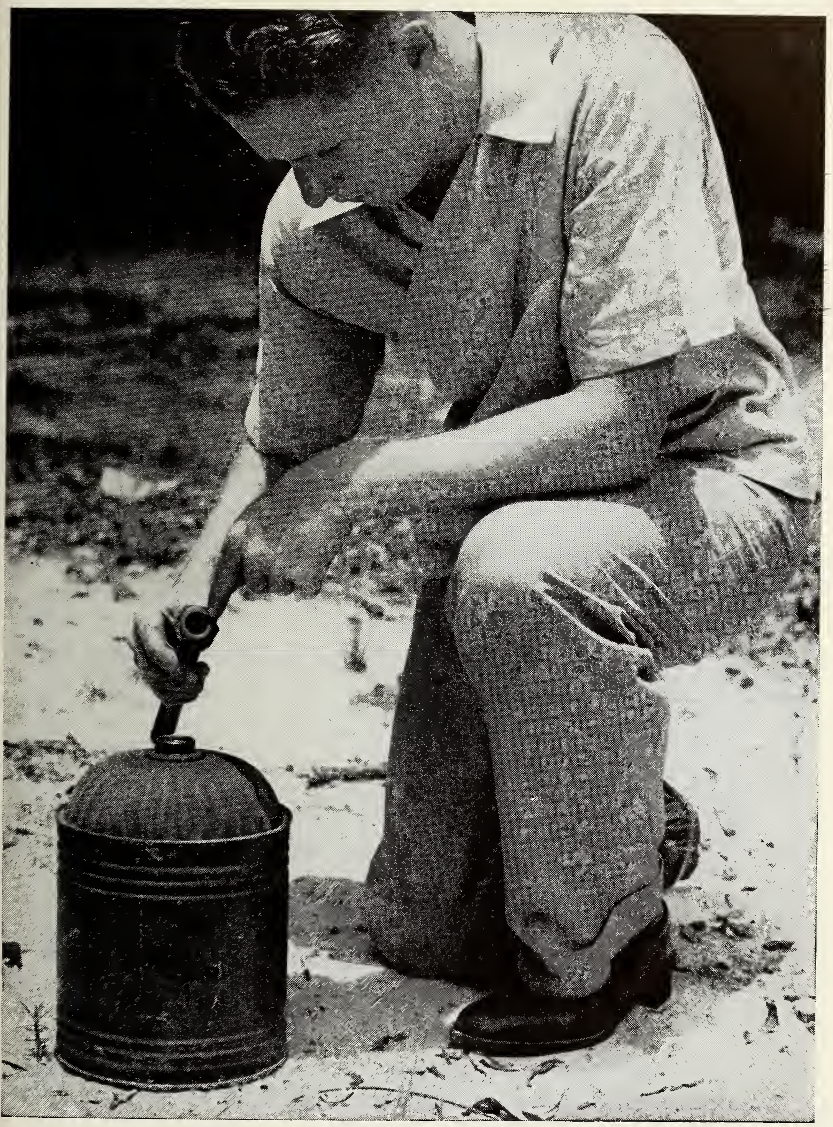

Fig. 56.—Lighter disassembled. The screen should be intact in the base of lighter spout.

the wick is kept lighted, and a little oil is spilled from the spout of the lighter into the heater or onto the kindling by tipping, and the fire from the wick lights this fuel.

The key to proper grove heating is always an adequate supply of accurate thermometers, properly mounted. Minimum recording thermometers can be obtained that are especially made for grove heating and checked for accuracy at temperatures from 20 to 35 degrees F. These will be rechecked by the Frost Warning Service each fall if brought to the designated point for collection by that organization. In order to read them correctly in the field they should be properly mounted 4-½ feet from the ground.

Specifications for Building Thermometer Shelter[1]

Bill of materials:

Dressed lumber, standard sizes:

One post—2" x 4" x 72"
One back—1" x 16-½" x 6"
One top—1" x 16-½" x 10"
Ends: Two triangular blocks made by cutting diagonally corner to corner 1 piece—1" x 8-¾" x 6"

Actual size of finished lumber:

Back—¾" x 16-½" x 5-½"
Top—¾" x 16-½" x 9-½"
Ends, before cutting into blocks—
¾" x 8-¾" x 5-½"

Use cypress or pine surfaced four sides and painted with two coats outside white lead paint. The post is creosoted at the bottom or treated with some other material to cut down decay and termite infestation.

Assembly: Nail triangular end blocks to back and fit top into place to complete thermometer shelter. If the minimum thermometer swings bulb upwards for setting, it will be necessary to hinge the top; otherwise the top can be nailed rigidly in place. Fasten the shelter on the post at top. Insert the post into the ground so that the thermometer bulb is 4-½ feet above the ground, facing the open side of the shelter toward the north. Mount the minimum thermometer on the back of the shelter so that the bulb end is about one inch lower than the upper end (Fig. 57). Place the shelter in the open between tree rows and away from grove heaters. Use flashlight for night reading.

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[1] Specifications taken from Frost Service Grower's Handbook of the Federal-State Horticultural Protection Service.

Plenty of thermometers should always be on hand, and these should be checked every fall. A number of thermometers should be placed in each block to be heated, and an extra thermometer should be placed outside the grove on the north side to indicate the temperature outside the grove. These thermometers should always be used as a guide to firing.

The exact temperatures at which to start the fires are difficult to put down in a specific form because so many different factors are involved. It was formerly believed that fruit should be kept above 28 degrees F., but with the changed nutritional program it has been found that fruit will stand considerably more cold than this without injury, but this figure is still a safe one to use where valuable crops are to be protected. When the crop has been picked and only the trees are to be protected and they are in reasonably dormant condition, the temperature can be allowed to reach 25 degrees F. before firing is started, and this temperature should be maintained. When trees are trying to grow, a somewhat higher temperature will be required for good protection.

For the convenience of the growers, the U. S. Weather Bureau and the Florida Agricultural Experiment Station operate a frost forecasting service at Lakeland, Florida. It publishes daily a weather bulletin during the winter and in cold weather forecasts actual temperatures to be expected in various locations in the state. The bulletin may be subscribed to and received by telegraph or heard on the radio. Information concerning prospective cold weather is given as far in advance as possible so that growers may make last minute preparations for firing.

Grove heating at best is very difficult and trying work, and every effort should be made to be thoroughly prepared in advance. Preparing to fire at the last minute is almost always a failure and may be very expensive. Increasing scarcity of satisfactory wood and high prices for oil and coke have greatly reduced preparations for heating in Florida and even in California there appears to be considerable reduction.

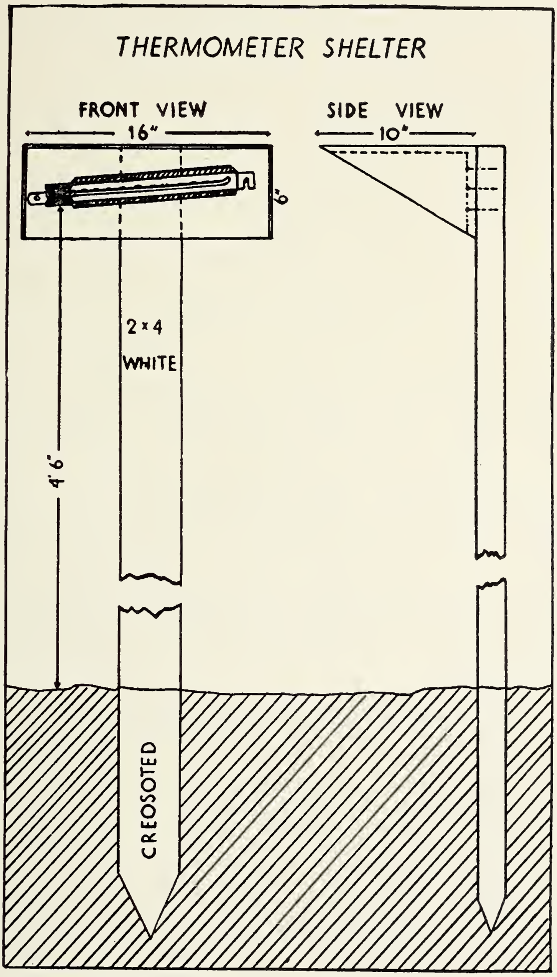

Fig. 57.—Standard thermometer shelter for use in grove heating. (From Frost Service Grower's Handbook for 1937-1938 by the Federal-State Horticultural Protection Service.)

Production Costs and Returns

Growers and prospective growers are always interested in the financial aspects of citrus growing. While no attempt will be made in this bulletin to analyze this phase of the problem in detail, some data are included which give a general picture of the situation. Mr. Zack Savage, Associate Agricultural Economist of the Agricultural Experiment Station, has provided two complete tables covering the period from 1931 to 1951. In Table VII will be found an analysis of orange costs and in Table VIII an analysis of grapefruit costs compiled from the records of representative groves.

In examining these figures, it should be taken into consideration that they cover a wide range of conditions: 1931-1942 was the period when the fertilizer program was being changed and gradually increasing production can be noted; 1942-1946 includes the war years when prices and profits were high, as they were in many industries; and 1946-1948 covered the post-war slump brought on by unsettled financial conditions in the country, plus the stoppage of government purchases of citrus products.

It will be noted that costs and returns are calculated both on a per-acre and a per-box basis. Since the grower sells fruit by the box, the latter figures are the more interesting. Actually, analyses of cost data indicate that extremely low "per acre" figures are frequently associated with high "per box" figures and low profits. In other words, a grower must invest in intelligent grove care in order to obtain profits. High costs per acre and high yields are commonly associated with high grove profits.

It should also be pointed out that the figures in the tables represent averages and are not necessarily indicative of the performance of any particular grove. Groves vary widely in cold protection, soil fertility, varieties and rootstocks, things that can not be entirely corrected by

TABLE VII—PER ACRE AND PER BOX COSTS, RETURNS AND OTHER DATA BY SEASONS FOR ORANGE GROVES AVERAGING OVER 10 YEARS OF AGE

	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41
Number of grove records	9	22	38	28	38	47	49	41	46	47
Total acres of groves	160	346	614	361	512	680	875	774	797	1086
Average acres per grove	18	16	16	13	13	14	18	19	17	23
Average age	18	20	19	19	18	18	20	20	21	21
Number of trees per acre	62	60	62	64	65	65	66	63	63	66
Percent of trees oranges	97.9	98.2	96.5	98.7	99.2	98.3	97.9	98.0	97.8	96.4
Boxes harvested per acre	139	148	112	143	158	169	197	247	223	227
Costs per **acre**:										
Labor, power, and equipment	$ 20.62	$ 24.70	$ 23.22	$ 19.07	$ 23.43	$ 24.66	$ 25.68	$ 29.66	$ 31.60	$ 37.55
Fertilizer materials	29.45	27.69	21.98	32.69	24.51	26.02	33.32	31.50	24.25	25.65
Spray and dust materials	2.57	3.87	3.65	4.13	3.57	4.44	6.27	5.71	5.55	6.25
State and county taxes	11.66	7.76	6.03	4.68	6.90	5.56	6.44	6.47	6.89	5.57
Miscellaneous	.96	.97	.66	.68	9.24	5.98	4.01	5.07	6.36	8.10
Total operating costs	65.26	64.99	55.54	61.25	67.65	66.66	75.72	78.41	74.65	83.12
Interest on grove valuation @ 6%	46.47	58.87	42.71	42.60	43.10	42.14	40.45	37.83	37.96	33.73
Total cost without owner supervision	111.73	123.86	98.25	103.85	110.75	108.80	116.17	116.24	112.61	116.85
Returns per acre:										
Returns from fruit	179.28	83.50	99.97	110.79	196.39	250.50	116.69	135.78	139.82	173.94
Net returns	67.55	—40.36	1.72	6.94	85.64	141.70	.52	19.54	27.21	57.09
Returns above operating costs	114.02	18.51	44.43	49.54	128.74	183.84	40.97	57.37	65.17	90.82
Costs per **box**:										
Labor, power, and equipment	.15	.17	.21	.14	.15	.15	.13	.12	.15	.17
Fertilizer materials	.21	.18	.20	.23	.16	.15	.17	.13	.11	.11
Spray and dust materials	.02	.03	.03	.03	.02	.02	.03	.02	.02	.03
State and county taxes	.08	.05	.05	.03	.04	.03	.03	.03	.03	.02
Miscellaneous	.01	.01	.01	*	.06	.04	.02	.02	.03	.04
Total operating costs	.47	.44	.50	.43	.43	.39	.38	.32	.34	.37
Interest on grove valuation @ 6%	.34	.40	.38	.30	.27	.25	.21	.15	.17	.15
Total costs without owner supervision	.81	.84	.88	.73	.70	.64	.59	.47	.51	.52
Returns per **box**:										
Returns from fruit	1.29	.57	.90	.78	1.24	1.48	.59	.55	.63	.77
Net returns	.48	—.27	.02	.05	.54	.84	*	.08	.12	.25
Returns above operating costs	.82	.13	.40	.35	.81	1.09	.21	.23	.29	.40

*Less than $0.005.

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TABLE VII—PER ACRE AND PER BOX COSTS, RETURNS AND OTHER DATA BY SEASONS FOR ORANGE GROVES AVERAGING OVER 10 YEARS OF AGE

	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51
Number of grove records	47	46	47	52	48	49	48	43	50	50
Total acres of groves	1048	992	1060	1133	1157	1255	1262	1035	1115	1167
Average acres per grove	22	22	23	22	24	26	26	24	22	23
Average age	22	22	22	21	22	23	24	26	27	27
Number of trees per acre	67	68	66	67	67	68	67	69	67	67
Percent of trees oranges	96.9	96.9	96.8	97.4	97.3	97.1	96.7	96.6	96.9	96.7
Boxes harvested per acre	234	287	332	267	347	329	346	339	330	344
Costs per acre:										
Labor, power, and equipment	$ 39.13	$ 41.74	$ 48.33	$ 52.61	$ 67.83	$ 87.43	$ 96.09	$ 76.08	$ 70.37	$ 76.70
Fertilizer materials	24.30	39.90	46.21	51.19	52.77	63.63	61.02	50.02	52.98	58.81
Spray and dust materials	7.30	10.16	9.71	10.22	10.22	11.16	11.88	11.13	8.11	12.04
State and county taxes	5.52	5.13	5.59	5.29	5.99	6.89	9.95	11.02	11.25	10.88
Miscellaneous	3.38	7.92	8.39	8.15	8.51	9.56	14.29	15.77	6.24	11.68
Total operating costs	79.63	104.85	118.23	127.46	145.32	178.67	193.23	164.02	148.95	170.11
Interest on grove valuation @ 6%	33.70	31.33	31.56	36.88	36.31	40.95	43.17	41.71	43.62	61.96
Total cost without owner supervision	113.33	136.18	149.79	164.34	181.63	219.62	236.40	205.73	192.57	232.07
Returns per acre:										
Returns from fruit	273.11	528.90	621.55	626.61	858.00	300.09	185.21	536.89	695.92	526.21
Net returns	159.78	392.72	471.76	462.27	676.37	80.47	—51.19	331.16	503.35	294.14
Returns above operating costs	193.48	424.05	503.32	499.15	712.68	121.42	—8.02	372.87	546.97	356.10
Costs per box:										
Labor, power, and equipment	.17	.14	.14	.20	.20	.27	.28	.22	.22	.22
Fertilizer materials	.11	.13	.14	.19	.15	.19	.18	.15	.16	.17
Spray and dust materials	.03	.04	.03	.04	.03	.03	.03	.03	.02	.04
State and county taxes	.02	.02	.02	.02	.02	.02	.03	.03	.03	.03
Miscellaneous	.01	.03	.03	.03	.02	.03	.04	.05	.02	.03
Total operating costs	.34	.36	.36	.48	.42	.54	.56	.48	.45	.49
Interest on grove valuation @ 6%	.14	.11	.10	.14	.10	.13	.12	.12	.13	.18
Total costs without owner supervision	.48	.47	.46	.62	.52	.67	.68	.60	.58	.67
Returns per box:										
Returns from fruit	1.17	1.84	1.88	2.35	2.47	.91	.54	1.58	2.11	1.53
Net returns	.69	1.37	1.42	1.73	1.95	.24	—.14	.98	1.53	.86
Returns above operating costs	.83	1.48	1.52	1.87	2.05	.37	—.02	1.10	1.66	1.04

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TABLE VIII—PER ACRE AND PER BOX COSTS, RETURNS, AND OTHER DATA BY SEASONS FOR GRAPEFRUIT GROVES AVERAGING OVER 10 YEARS OF AGE

	1931-32	1932-33	1933-34	1934-35	1935-36	1936-37	1937-38	1938-39	1939-40	1940-41
Number of grove records	5	6	6	8	9	8	9	8	9	10
Total acres of groves	31	46	46	68	78	68	83	77	89	97
Average acres per grove	6	8	8	8	9	8	9	10	10	10
Average age	15	16	19	19	19	21	20	20	20	20
Number of trees per acre	62	63	63	62	62	62	69	68	69	62
Percent of trees grapefruit	100.0	100.0	100.0	99.2	98.4	99.2	99.1	98.7	98.2	98.6
Boxes harvested per acre	269	228	144	339	134	330	249	381	266	441
Costs per acre:										
Labor, power, and equipment	$ 37.39	$ 46.27	$ 33.32	$ 25.36	$ 30.95	$ 36.51	$ 29.82	$ 40.55	$ 22.61	$ 40.53
Fertilizer materials	66.83	49.11	33.48	39.28	38.23	43.11	54.73	46.11	32.09	31.15
Spray and dust materials	8.34	9.57	12.41	7.67	6.49	8.46	8.46	11.15	6.22	8.89
State and county taxes	11.71	8.71	9.14	8.33	10.89	8.69	8.62	6.02	4.76	5.76
Miscellaneous	1.54	.76	.14	.11	7.75	4.24	3.30	9.95	6.59	4.17
Total operating costs	125.81	114.42	88.49	80.75	94.31	101.01	104.93	113.78	72.27	90.50
Interest on grove valuation @ 6%	28.99	29.00	39.87	28.26	26.65	28.14	24.54	21.58	23.06	25.46
Total cost without owner supervision	154.80	143.42	128.36	109.01	120.96	129.15	129.47	135.36	95.33	115.96
Returns per acre:										
Returns from fruit	127.32	73.53	96.51	75.02	73.94	175.79	130.06	74.75	117.51	147.86
Net returns	27.48	— 69.89	—31.85	—33.99	—47.02	46.64	.59	—60.61	22.18	31.90
Returns above operating costs	1.51	— 40.89	8.02	— 5.73	- 20.37	74.78	25.13	—39.03	45.24	57.36
Costs per box:										
Labor, power, and equipment	.14	.20	.23	.08	.23	.11	.12	.10	.09	.09
Fertilizer materials	.24	.22	.23	.12	.29	.12	.23	.12	.12	.07
Spray and dust materials	.03	.04	.09	.02	.05	.03	.03	.03	.02	.02
State and county taxes	.04	.04	.06	.02	.08	.03	.03	.02	.02	.01
Miscellaneous	.01	*	*	*	.06	.01	.01	.03	.02	.01
Total operating costs	.46	.50	.61	.24	.71	.30	.42	.30	.27	.20
Interest on grove valuation @ 6%	.11	.13	.28	.08	.20	.09	.10	.06	.09	.06
Total cost without owner supervision	.57	.63	.89	.32	.91	.39	.52	.36	.36	.26
Returns per box:										
Returns from fruit	.47	.32	.67	.22	.56	.53	.52	.20	.44	.33
Net returns	—.10	—.31	—.22	—.10	—.35	.14	*	—.16	.08	.07
Returns above operating costs	.01	—.18	.06	—.02	—.15	.23	.10	—.10	.17	.13

*Less than $0.005.

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TABLE VIII—PER ACRE AND PER BOX COSTS, RETURNS, AND OTHER DATA BY SEASONS FOR GRAPEFRUIT GROVES AVERAGING OVER 10 YEARS OF AGE

	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51
Number of grove records	11	11	10	11	11	12	9	8	7	7
Total acres of groves	106	184	174	189	188	193	88	73	63	63
Average acres per grove	10	17	17	17	17	16	10	9	9	9
Average age	20	21	22	22	23	24	27	29	31	31
Number of trees per acre	68	60	60	61	61	61	70	70	69	69
Percent of trees grapefruit	98.4	99.0	98.9	98.6	98.6	98.4	97.3	97.8	98.8	98.6
Boxes harvested per acre	429	321	354	275	456	367	463	481	241	548
Costs per acre:										
Labor, power, and equipment	$ 45.17	$ 29.90	$ 46.56	$ 47.60	$ 66.18	$ 93.04	$102.56	$ 63.84	$ 90.29	$107.86
Fertilizer materials	34.76	44.58	52.96	68.82	70.22	78.84	80.75	48.73	62.43	80.53
Spray and dust materials	9.42	11.45	11.41	11.86	12.25	20.21	13.60	17.03	17.54	31.67
State and county taxes	7.22	5.15	5.52	5.43	5.98	6.28	12.39	12.59	13.55	11.74
Miscellaneous	.11	3.09	4.59	3.69	3.00	3.35	8.75	8.77	2.57	11.89
Total operating costs	96.68	94.17	121.04	137.40	157.63	201.72	218.05	150.96	186.38	243.69
Interest on grove valuation @ 6%	25.00	18.32	18.00	18.43	20.81	24.19	29.88	26.15	26.96	52.97
Total cost without owner supervision	121.68	112.49	139.04	155.83	178.44	225.91	247.93	177.11	213.34	296.66
Returns per acre:										
Returns from fruit	347.67	292.63	418.07	383.10	491.14	204.38	103.90	313.45	370.98	283.04
Net returns	225.99	180.14	279.03	227.27	312.70	—21.53	—144.03	136.34	157.64	—13.62
Returns above operating costs	250.99	198.46	297.03	245.70	333.51	2.66	—114.15	162.49	184.60	39.35
Costs per **box**:										
Labor, power, and equipment	.10	.09	.13	.18	.15	.25	.22	.13	.37	.20
Fertilizer materials	.08	.14	.15	.25	.15	.21	.17	.10	.26	.15
Spray and dust materials	.02	.04	.03	.04	.03	.06	.03	.03	.07	.06
State and county taxes	.02	.02	.02	.02	.01	.02	.03	.03	.06	.02
Miscellaneous	*	.01	.01	.01	.01	.01	.02	.02	.01	.02
Total operating costs	.22	.30	.34	.50	.35	.55	.47	.31	.77	.45
Interest on grove valuation @ 6%	.06	.05	.05	.07	.04	.07	.06	.06	.11	.09
Total cost without owner supervision	.28	.35	.39	.57	.39	.62	.53	.37	.88	.54
Returns per **box**:										
Returns from fruit	.81	.91	1.18	1.39	1.08	.56	22	.65	1.54	.52
Net returns	.53	.56	.79	.82	.69	—.06	—.31	.28	.66	—.02
Returns above operating costs	.59	.61	.84	.89	.73	.01	—.25	.34	.77	.07

*Less than $0.005.

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treatment, so each grove should be examined on its own record in purchasing.

Many prospective growers are interested in the cost of producing a new grove and Mr. Savage has kindly provided the following text and table on this problem:

"The Florida Agricultural Extension Service and Agricultural Experiment Stations receive numerous requests from time to time for information on costs of citrus plantings. While complete data are not available, it is believed the information here presented will be help-

TABLE IX—PER ACRE AND PER BOX COSTS, RETURNS, AND OTHER DATA BY 5-YEAR PERIODS FOR GROVES AVERAGING OVER 10 YEARS OF AGE

	1931-36	1936-41	1941-46	1946-51
Number of grove records	159	266	230	205
Total acres of records	5041	9234	8140	7292
Average acres per grove	32	35	35	36
Average age	18	19	23	26
Number of trees per acre	59	60	62	62
Percent trees grapefruit	31.8	31.1	31.6	30.7
Boxes harvested per acre	126	175	250	314
Costs per **acre**:				
Labor, power, and equipment	22.70	23.19	41.40	72.67
Fertilizer materials	23.35	23.22	39.28	48.12
Spray and dust materials	3.33	4.75	7.54	11.47
State and county taxes	6.47	4.83	4.42	8.62
Miscellaneous	1.39	2.11	5.56	7.51
Total operating costs	57.24	58.10	98.20	148.39
Interest on grove valuation @ 6%	37.91	30.53	30.55	42.31
Total cost without owner supervision	95.15	88.63	128.75	190.70
Returns per **acre**:				
Returns from fruit	93.45	102.02	420.70	328.95
Net returns	—1.70	13.39	291.95	138.25
Returns above operating costs	36.21	43.92	322.50	180.56
Costs per **box**:				
Labor, power, and equipment	.18	.13	.16	.23
Fertilizer materials	.19	.13	.16	.15
Spray and dust materials	.03	.03	.03	.04
State and county taxes	.05	.03	.02	.03
Miscellaneous	.01	.01	.02	.02
Total operating costs	.46	.33	.39	.47
Interest on grove valuation @ 6%	.30	.17	.12	.14
Total cost without owner supervision	.76	.50	.51	.61
Returns per **box**:				
Returns from fruit	.75	.58	1.68	1.05
Net returns	—.01	.08	1.17	.44
Returns above operating costs	.29	.25	1.29	.58

(From "Twenty Years of Citrus Costs and Returns in Florida, 1931-51," by Zack Savage, Assoc. Economist, Fla. Agr. Exp. Stn.)

ful in answering many such questions by indicating approximate costs during the period of 1948-53.

"Variations in costs at different price levels and for individual plantings are so wide that it is difficult to arrive at figures that apply at all times and under all circumstances. Changes in the general price level cause fluctuations in costs and returns, and such fluctuations should be taken into account when applying figures at a given time or to a particular situation.

"The price of raw land to be used for grove purposes is an important consideration. The location of a grove with reference to accessibility for grove operations, as well as to fruit marketing facilities, is important and will be reflected in land prices. Some other considerations in selecting land and site for a grove are type of soil, subsoil, state of fertility, air and water drainage, natural frost protection, availability of water for irrigation purposes, topography, and cost of preparing land for setting trees.

"Data on young citrus groves for which we have records are shown in Table X."

TABLE X—DATA ON COST OF PLANTING, DEVELOPING, YIELD AND RETURNS FROM FRUIT ON FLORIDA MIXED CITRUS GROVES THROUGH 10 YEARS OF AGE[1]

	Age in Years from Setting										
	Up to 1 Year	1	2	3	4	5	6	7	8	9	10
1946-51- Yield—Boxes per acre:	0	0	0	29	58	87	116	145	174	203	232
Costs per acre:											
Land[2]	$100.00										
Clearing land[2]	100.00										
Tree @ $1.25[3]	87.50										
Setting trees	22.50										
Watering[2]	20.50										
Cover crop seed	3.50										
Labor, power, and equipment	$ 28.50	$ 31.50	$ 34.50	$ 37.50	$ 40.50	$ 43.50	$ 46.50	$ 49.50	$ 52.50	$ 55.50	$ 58.50
Fertilizer materials	8.00	11.65	15.30	18.95	22.60	26.25	29.90	33.55	37.20	40.85	44.50
Spray and dust materials	0.00	0.50	1.00	2.40	3.80	5.20	6.60	8.00	9.40	10.80	12.20
State and county taxes	1.50	1.80	2.10	2.40	2.70	3.00	3.56	4.12	4.68	5.24	5.80
Miscellaneous	5.00	5.30	5.60	5.90	6.20	6.50	6.80	7.10	7.40	7.70	8.00
Total operating costs	377.00	50.75	58.50	67.15	75.80	84.45	93.36	102.27	111.18	120.09	129.00
Returns per acre:											
Returns—1948-53 on-tree price	0.00	0.00	0.00	34.80	69.60	104.40	139.20	174.00	208.80	243.60	278.40
Returns above operating costs	—377.00	—50.75	—58.50	—32.35	—6.20	19.95	45.84	71.73	97.62	123.51	149.40

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[1] On groves with one-third of trees grapefruit.

[2] These costs vary considerably with location and conditions.

[3] One-third of trees grapefruit. Costs of nursery stock vary considerably with kind and variety.

PART II

PACKING HOUSE OPERATION

By

A. F. Camp

Vice-Director in Charge, Citrus Experiment Station

Citrus fruit is usually harvested by crews supplied by the packing house rather than by the grower himself or his laborers. Sales of fruit are usually on the "on tree" basis, with the packing house absorbing the cost of picking and hauling. A few large growers maintain their own picking crews and some caretakers maintain crews for picking fruit that is to go direct to the cannery, but in the main, practically all of the fruit is removed from the trees by packing house crews trained for this purpose or by independent buyers who maintain picking crews and who are commonly referred to as "bird dogs." Picking is usually piece work at so much per box, and is seldom paid for on the hour or day basis.

During the early season, or at the beginning of the season for late varieties, the first step before moving the crop is to determine whether it will pass the legal maturity standards enforced by the State Department of Agriculture. Under these standards, fruit must contain a certain percentage of juice, a minimum content of solids in the juice and exceed a specified ratio of solids to acid. Detailed information on the exact requirements may be obtained from the State Department of Agriculture in Tallahassee or their office in Winter Haven, Florida. This field testing is done by representatives of the packing house who carry samples of the crop to the packing house for examination. When it is desired to do some picking in a grove where the fruit is barely passing, and particularly if some sizes pass and others do not, a tester usually accompanies the picking crew and makes periodic tests while picking is in progress. Testing by the in-

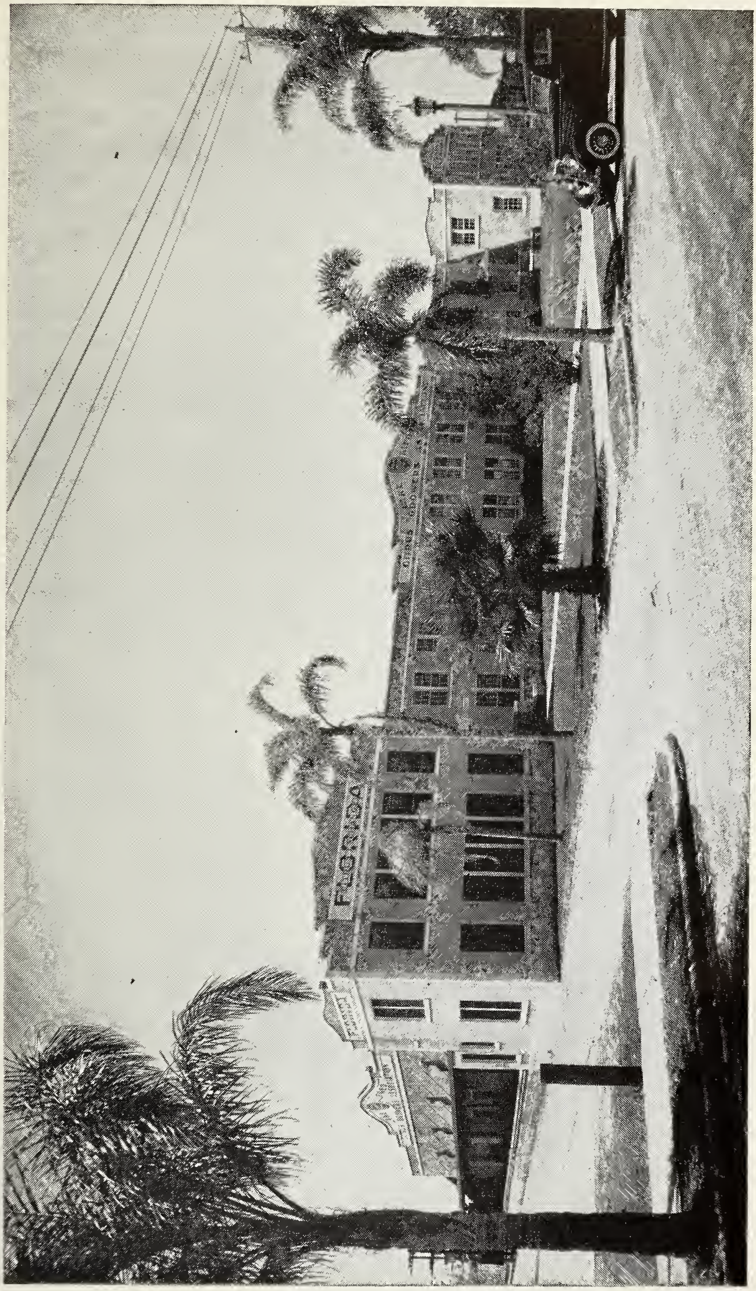


Fig. 58.—One of the many citrus packing houses in Florida.

spectors of the State Department of Agriculture is not done in the field but in the packing house or processing plant and the responsibility for determining whether a given crop should be picked or not is in the hands of the owner or buyer. If the crop is ready to move, field boxes are delivered to the grove by trucks, and are scattered through the grove as thickly as necessary. These boxes are standard containers of a size prescribed by law, containing roughly 90 pounds of fruit, though in the case of large-sized oranges and grapefruit, poundage contained in the box will be somewhat smaller. The size of the box was originally designated to contain enough fruit to pack out one standard shipping box containing 1-3/5 bushels. Under present conditions, when the lower grades go to the cannery instead of being packed, the number of packed boxes is usually below the number of picked boxes.

As soon as the dew dries from the trees, the picking crew removes the fruit. This was formerly done exclusively by clipping and the idea was prevalent that fruit would not carry to market if pulled. The first

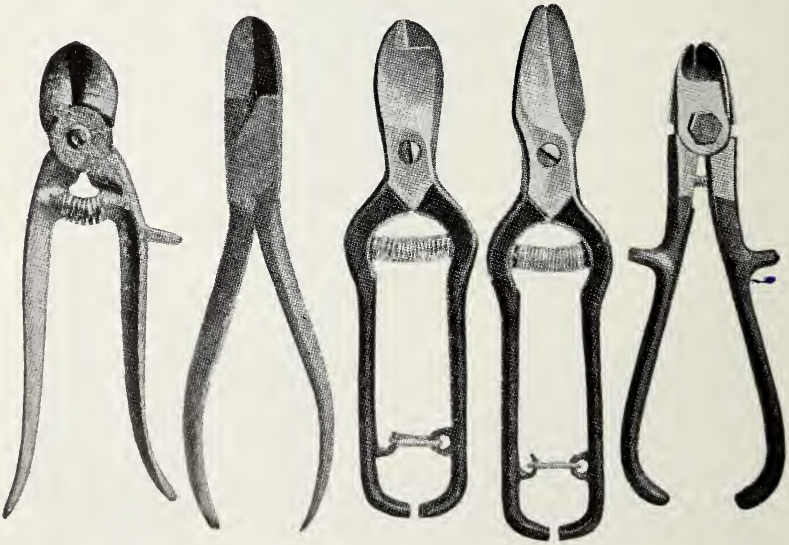


Fig. 59.—Various types of clippers. The short bladed clipper with guard shown on the right, is usually recommended. (From Cultivation of Citrus Fruits, by H. H. Hume, by permission of the Macmillan Company.)

clipper used had rather long blades and unless carefully used, would cut the fruit around the stem end, causing clipper cuts, which became infected later by blue or green mold, causing decay in transit. Later, short-bladed clippers with shields, commonly called "bull-nosed clippers," were developed, and prior to the war were used almost exclusively, and the shear type of clipper was not recommended (Fig. 59). Due to the shortage of labor during the war period, pulling was extensively substituted for clipping because of the greater speed with which the fruit can be removed from the tree. The procedure is not exactly pulling, because a straight pull of the fruit along the same axis as the twig to which it is attached frequently results in pulling out a portion of the peel along with the button or calyx, and decay is likely to set in. This is called "plugging." Instead of using a straight pull, pickers twist the fruit at an angle to the twig and then jerk downward sharply to remove it. Extensive tests have indicated that in oranges and grapefruit decay is no greater in properly pulled fruit than it is in carelessly clipped fruit. As far as oranges and grapefruit are concerned, the number of "plugs," in which a portion of the peel is pulled out of the fruit, about balances the clipper cuts obtained in careless picking. Since the war, many packing houses have returned to clipping, but oranges and grapefruit moving directly to the processing plant are pulled. Tangerines can not be pulled successfully because they "plug" too easily and are still being clipped.

As the picker removes fruit from the trees, he puts it into a bag which he carries at his side by means of a strap over his opposite shoulder. This bag has an open bottom, which is kept closed, while he is filling it, by doubling up the bottom to which a rope is attached and hooking the rope to a hook on the top hoop of the bag. When the bag is full, he transfers the fruit to the box by unhooking the rope and letting it down so that the bag opens at the bottom and the fruit flows easily into the box without bruising (Fig. 60). Since citrus trees are usually rather large, a high proportion of the fruit must be picked from ladders, and these are lightweight

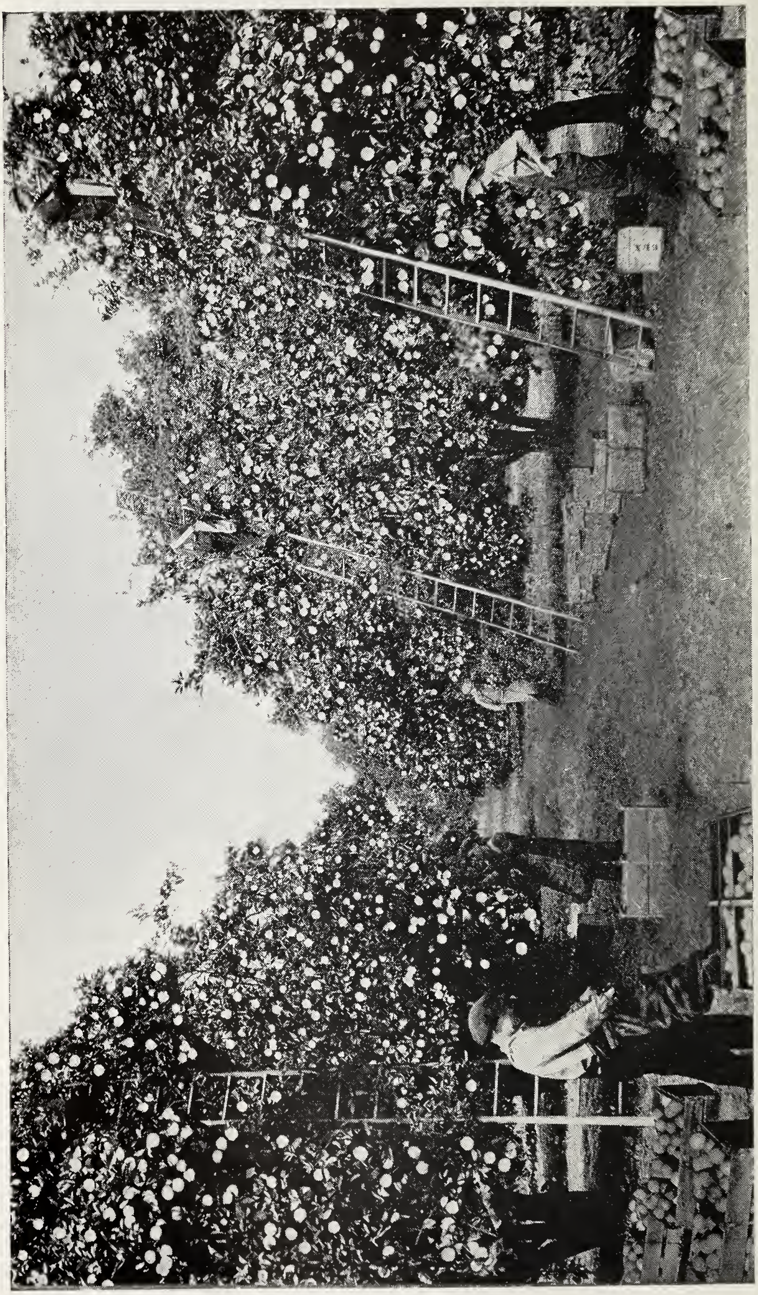


Fig. 60.—Picking the crop.

straight ladders which are leaned against the tree, and stepladders are never used.

When picking grapefruit for the cannery it is sometimes shaken from the tree and picked from the ground. This usually results in too much damage for the fresh fruit market and this method is used only when the fruit is to be moved direct to the cannery. Oranges are very resistant to shaking and must be picked.

The filled boxes are loaded on the trucks for hauling to the packing house, and if the distance is short, small trucks carrying a single row of boxes, and commonly referred to as "goats," are used for the direct haul, but where the haul is long, small trucks or tractor trailers are used to carry the fruit to the highway, where it is loaded on large trucks or semi-trailers. Fruit is frequently hauled long distances to the packing house, but such long hauls are usually made in the normal direction of fruit movement to the northern markets, and not in the reverse direction, as this would increase the transportation cost. Fruit boxes are usually loaded four high on the trucks, as this is considered a stack and is the number of boxes handled by the packing house hand truck.

When the fruit arrives at the packing house, it is unloaded by means of the hand trucks above-mentioned, and if it is early in the season, when the fruit is still green on the outside due to lack of cold weather, the fruit is stacked in the coloring or degreening rooms. It is held in these rooms for 24 to 70 hours, depending upon the degree of greenness and the temperature is maintained at about 85°F. and the humidity at about 85%, usually by means of hand controls. Fans circulate the air in the room while the degreening is in process. Ethylene, which bleaches out the green, is added to the room at a very low concentration, usually by a trickle applicator, which adds ethylene very slowly. The rooms are usually aired twice a day and sometimes oftener.

This degreening or "coloring" is occasioned by the fact that citrus fruit does not lose its green color and become yellow or orange as the case may be until some

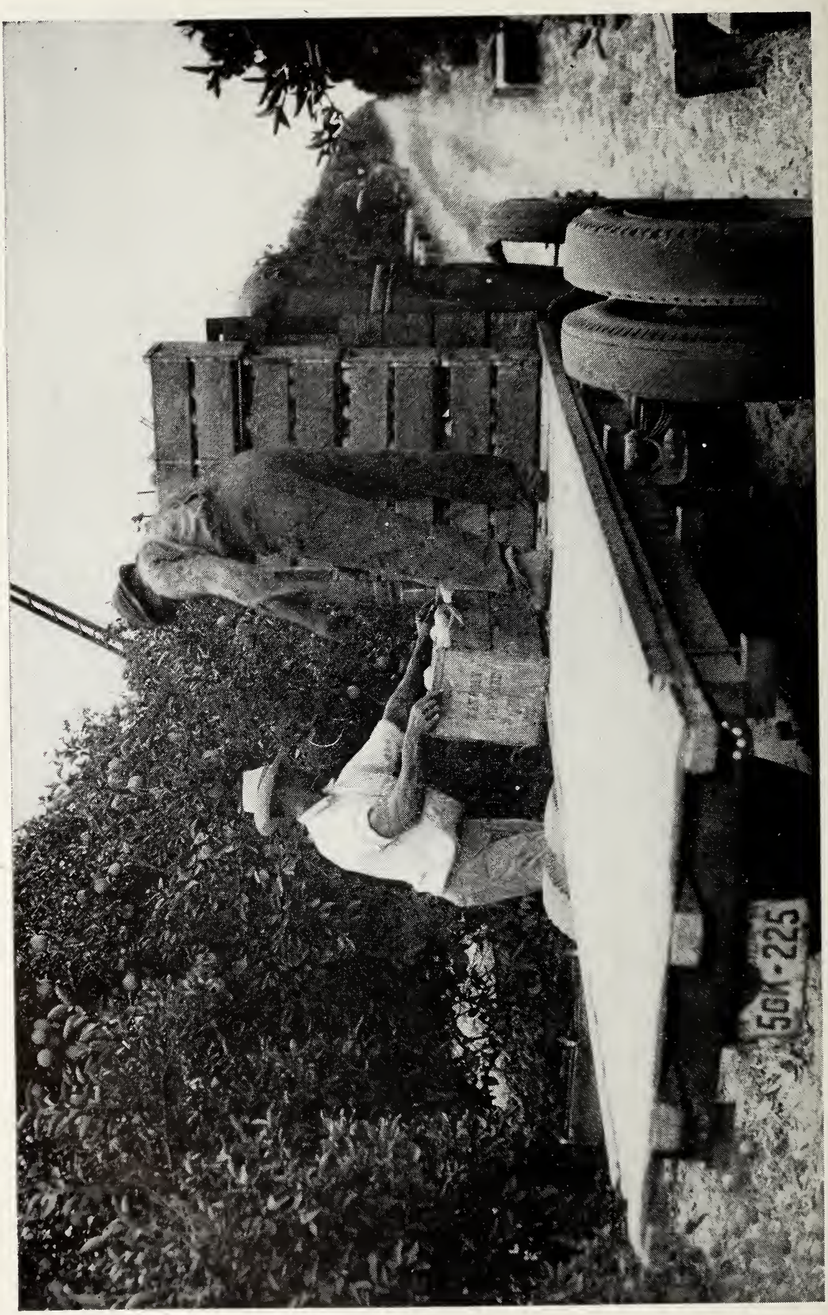


Fig. 61.—Loading fruit on grove truck.

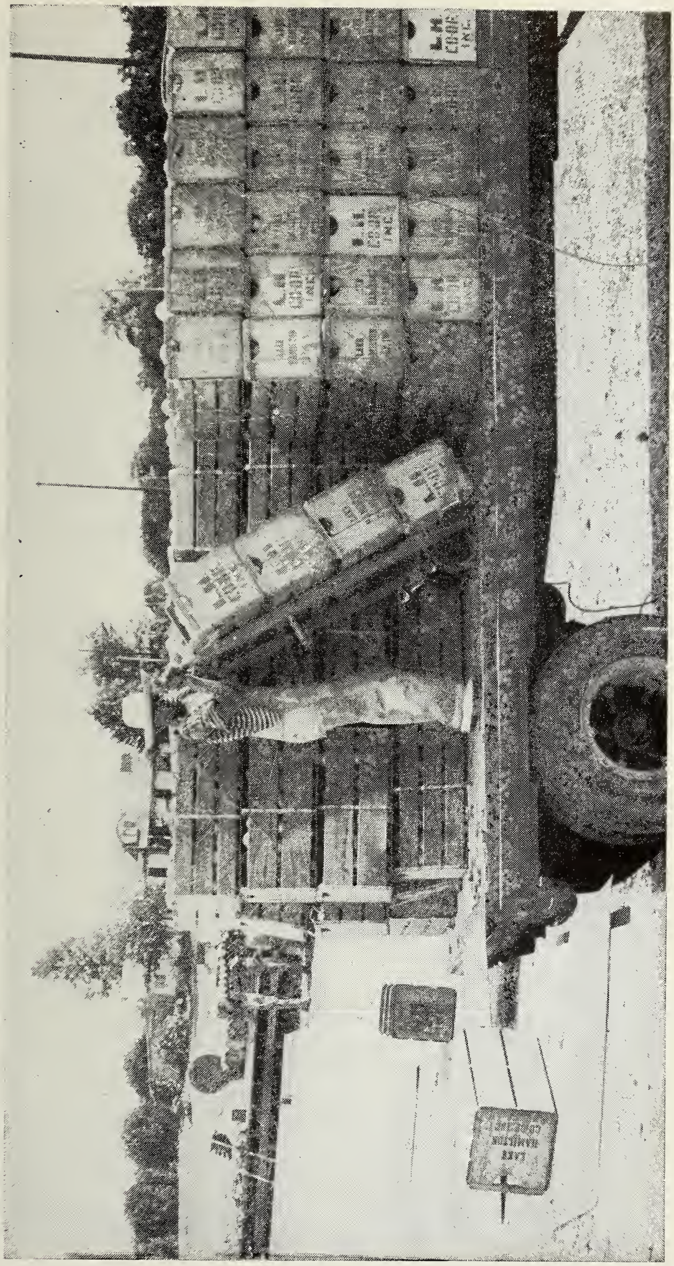


Fig. 62.—Unloading fruit at the packing house. Fruit is stacked four boxes high on the truck and handled by clamp trucks which carry four boxes.

cold weather has occurred. In the lower altitudes in the tropics, oranges never become deep orange-colored because of the lack of cold weather and the consequent failure of the green to disappear. In Florida the fruit of some varieties becomes edible before there has been sufficient cold to bleach out the green, and during this period the fruit contains the natural yellow in the rind but it is masked by the intense green color. The ethylene treatment bleaches out the green and allows the yellow to become the dominant color. It does not affect the inside of the fruit as far as is known, although an internal effect in increasing sugar content is known in bananas which are similarly treated. As soon as sufficient cold weather has occurred to bleach the green naturally, fruit is no longer treated with ethylene, and the time when this occurs varies from year to year and may be anywhere from the first of November to the middle of December, depending on the occurrence of cool weather. Warm humid weather in the spring and early summer also tends to cause ripe Valencias remaining on the tree to regreen and the Valencias may have to be treated with ethylene during the latter part of the season if conditions have been unusually favorable to vegetative growth.

After the ethylene treatment is finished, or directly after the fruit has been moved into the packing house in case ethylene is not needed, the fruit is usually dumped by hand or machine onto a conveyor belt which passes the fruit onto a short roller conveyor which allows the leaves and trash to drop through. From this it passes through a presizer which separates out the fruit which is either too large or too small to be shipped. These large and small sized fruits are carried by elevator to a bin for processing fruit and the remainder of the fruit goes to a tank containing water or to a roller conveyor which carries the fruit under a series of water sprays. The fruit as it comes from the grove carries on its surface considerable dust, spray residue, scale and, where whiteflies have been numerous, may have considerable of the sooty mold fungus. The function of the soak tank or the spray is to wet the surface of the fruit and

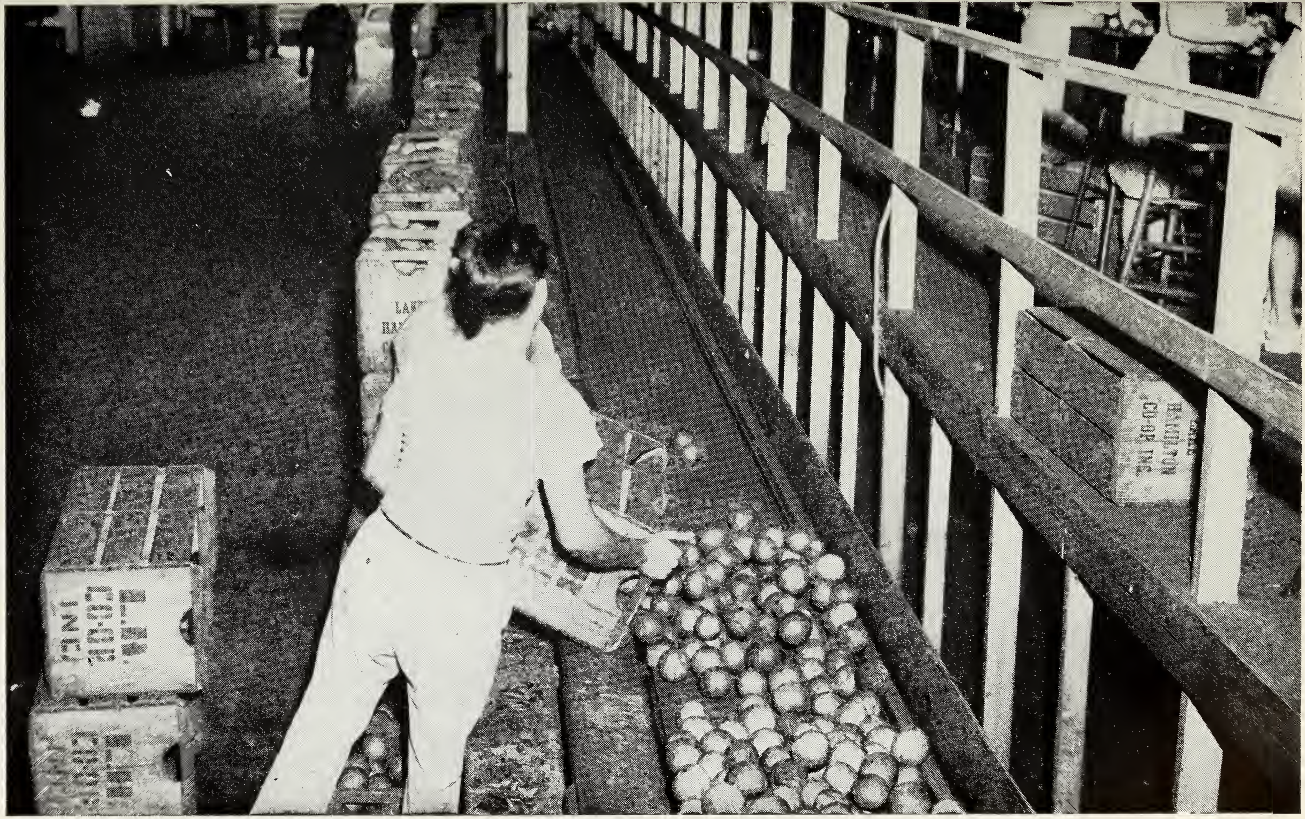


Fig. 63.—Dumping fruit into a dumpbelt which carries the fruit to a short roller conveyor to allow the twigs and leaves to drop through to the floor before the fruit reaches the washer.

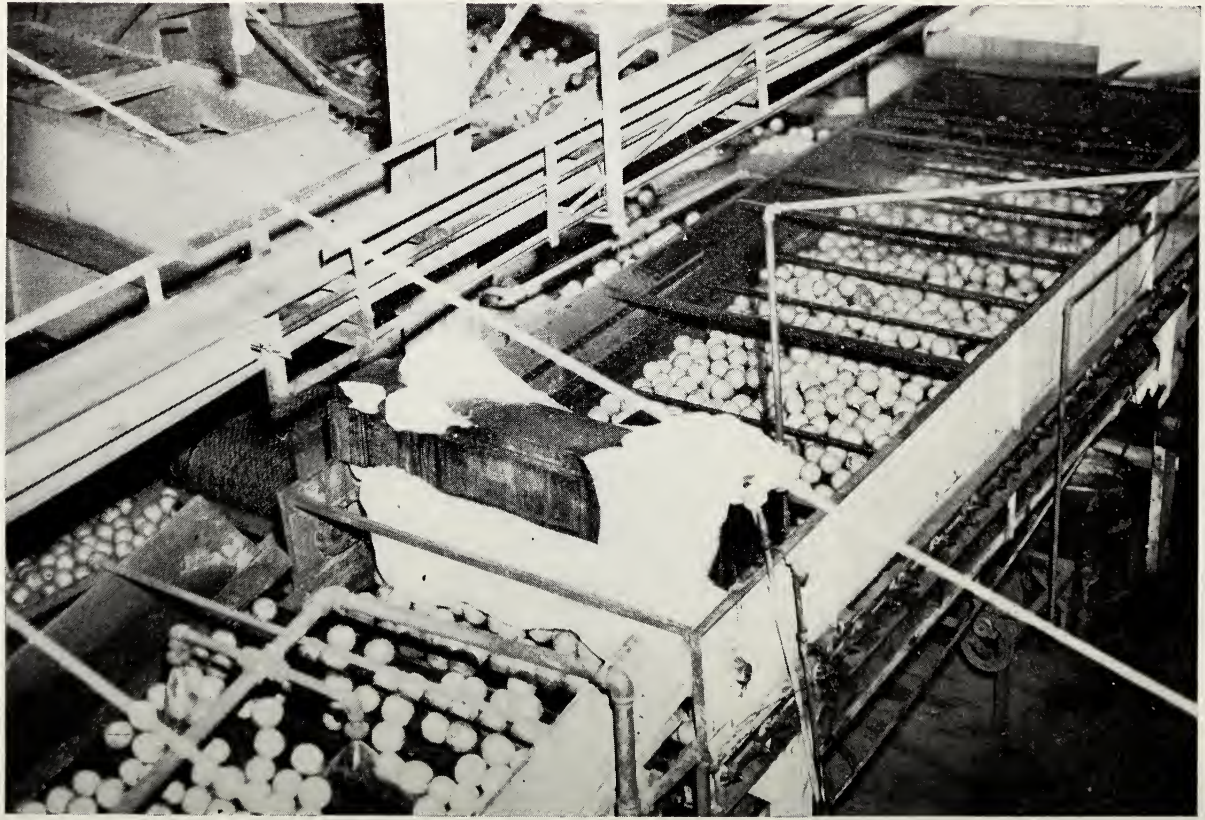


Fig. 64.—Fruit washer. On the left the fruit is being sprayed with water on a roller conveyor. As it reaches the rotating brushes it is soaped with suds from a compressed air sudser

allow loose dirt to wash off. Disinfectants are sometimes used in such tanks and occasionally water conditioners, but generally water alone is used, and this is renewed daily with fresh water as the tank accumulates considerable mud. The tendency at the present time is to eliminate the soak tank and use the roller conveyor with the water spray, as shown in Figure 64. From the wetting or soaking process, the fruit goes into the washer, which is made up of a series of cylindrical brushes with Tampico or palmetto bristles. These brushes rotate in the direction in which the fruit is moving, and as the fruit hits the first brush, it is soaped, either by means of soap solution or more generally by means of a sudser. The sudser contains a solution of soap or a soap substitute and suds are generated by bubbling air through it. The suds drip down on the fruit as shown in Figure 64. A good quantity of suds helps to remove the dirt on the surface of the fruit, and also reduces the friction between the fruit and the brushes and consequent damage. The fruit is moved through the washer by pressure from incoming fruit, and at the end of the washer is rinsed by means of a water spray. As it leaves the washer, it is commonly run over an eliminator, consisting of cylindrical brass rolls which are rotating and which have the water removed from them by rubber wipers on the under side. This eliminator removes excess moisture from the fruit but is not always used at this point. Leaving the washer, grapefruit move directly to the waxer or dryer, but oranges may be passed through a "color-added" application, which adds an orange-red dye to the surface of the fruit to intensify the color and thus improve the appearance of the fruit. The use of "color-added" is determined by the desire of the market to which the fruit is to be shipped, and part of the oranges move with "color-added" applied and part without. This is purely a surface application to the peel and does not penetrate into the fruit. The fruit is rinsed as it leaves the color applicator and runs over an eliminator, as above-mentioned, and proceeds to the dryer.

Dryers formerly consisted of roller conveyors in a tunnel, through which a current of warm air was forced by means of a fan or blower. In recent years, dryers, in

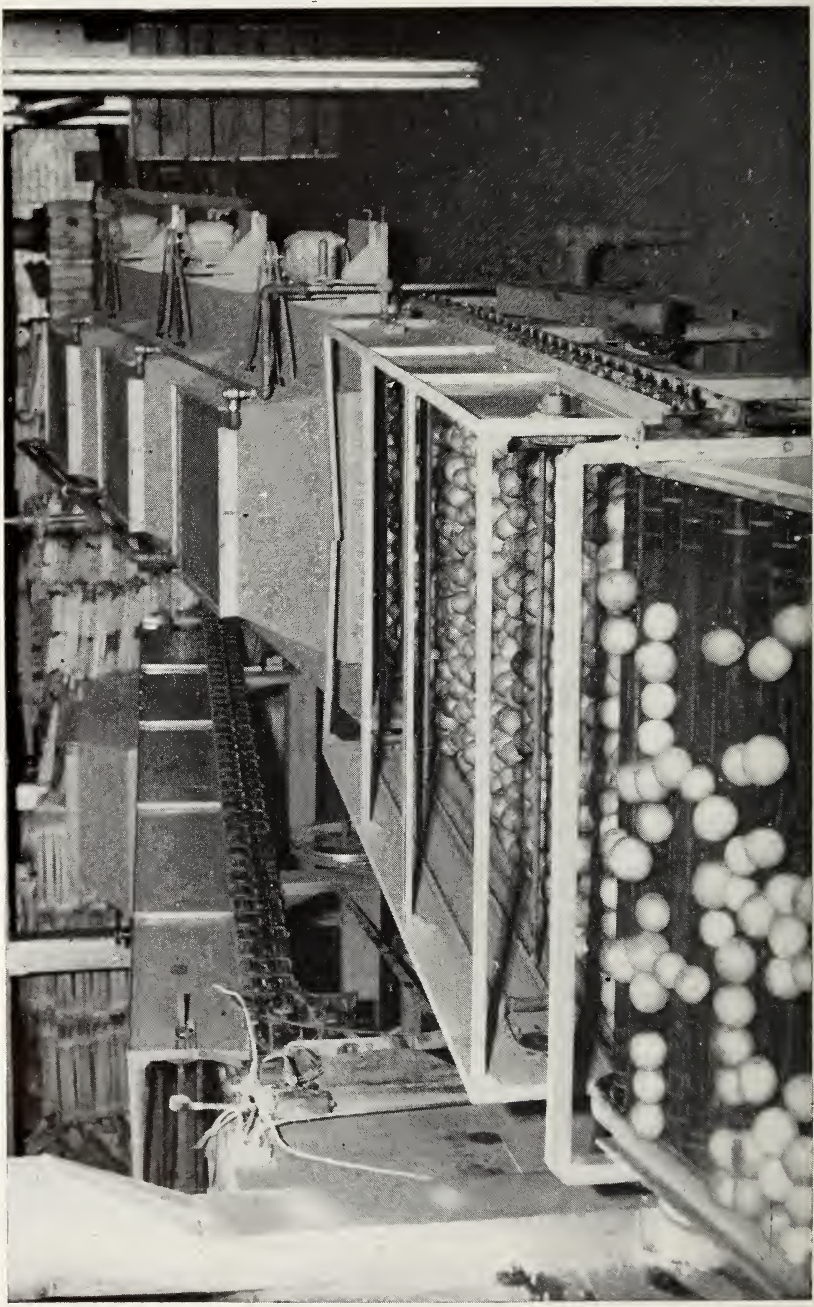


Fig. 65.—Citrus fruit dryer. Eliminator in foreground removes excess moisture and brush dryer with fans and steam radiators remove the remaining water.

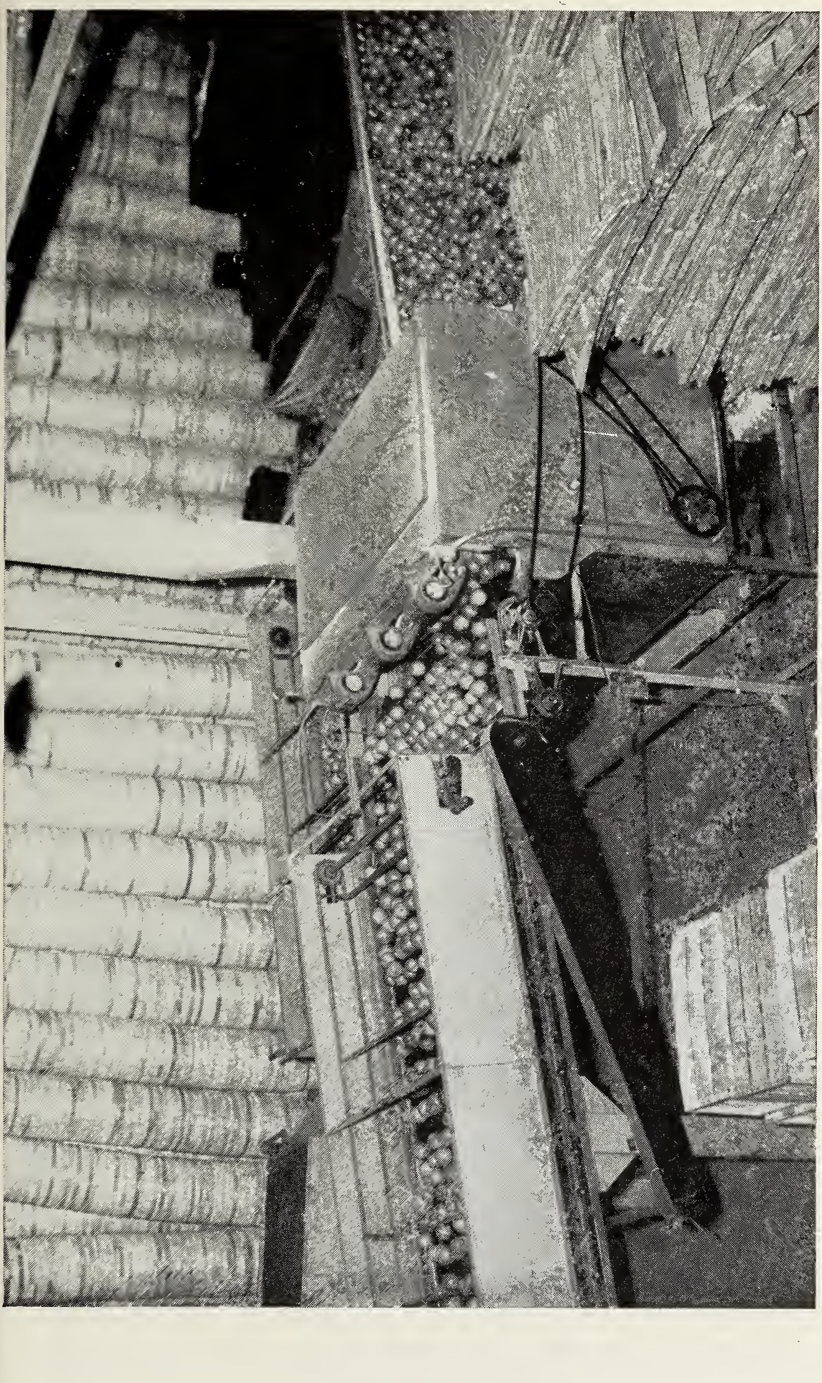
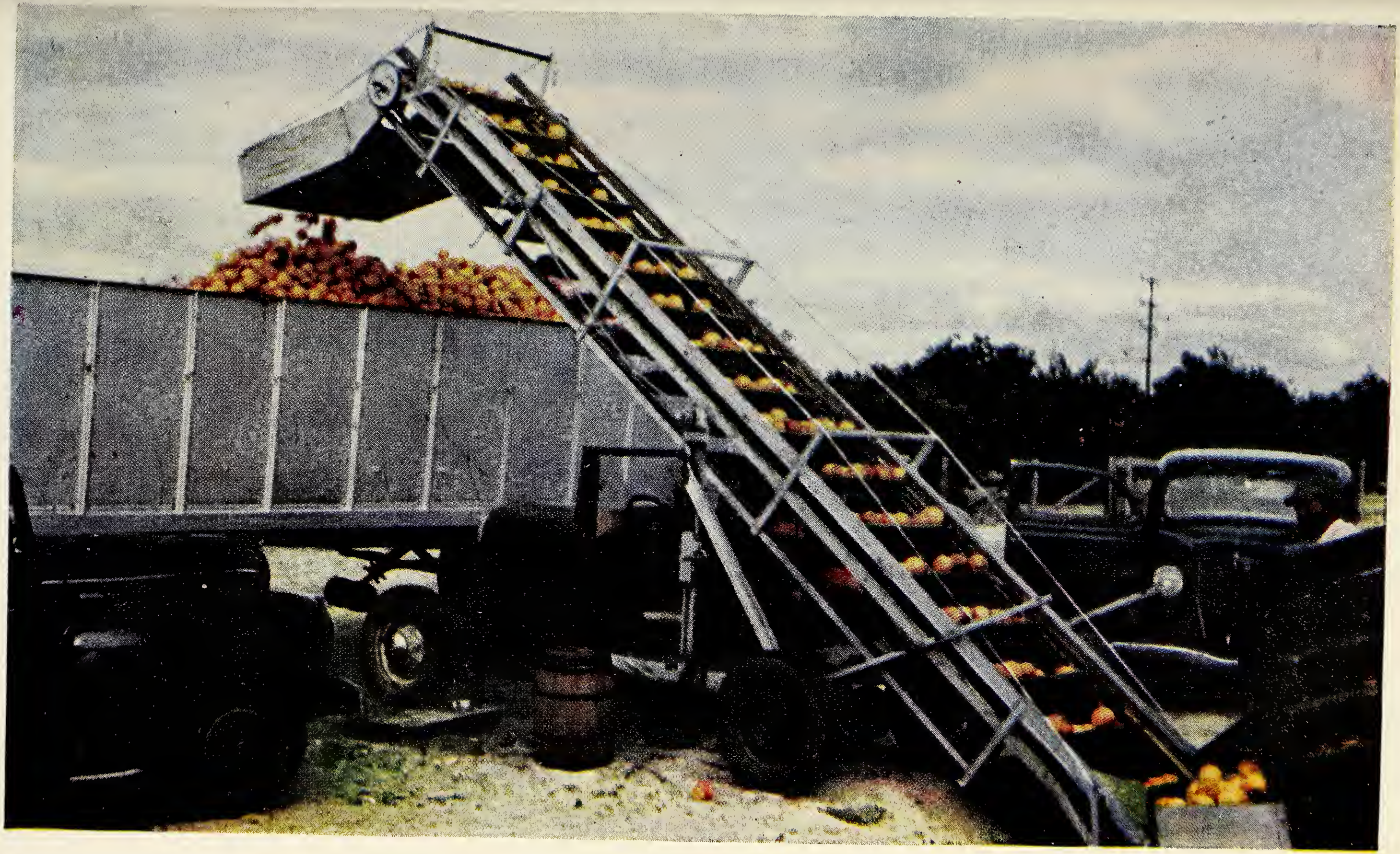


Fig. 66.—Horsehair brush polisher on left feeding dry fruit to the waxer at right.

which brushes with horsehair bristles are used to remove the moisture from the fruit, have been largely substituted for the air dryer. These dryers commonly consist of a large number of cylindrical horsehair brushes rotating rapidly, and above the dryer is a series of fans which force air down through the fruit and the brushes. Where large amounts of fruit are to be dried on days when the humidity is high, a network of steam pipes is commonly placed immediately below the fans or steam radiators above the fans so that the air is warmed before it reaches the fruit. From the dryer the fruit moves to the polisher, which has the same construction as the dryer, except that the fans are commonly omitted and the brushes are dry and create a polish on the fruit. From the polisher the fruit is delivered to the grading table.

Wax is usually applied at some stage before the fruit reaches the grading tables. Several types of waxing are used and are discussed here together rather than designating their place in the machinery lineup. Wax emulsions are very commonly used which contain paraffin and carnauba waxes emulsified in water by means of some emulsifying agent. These come in a concentrated form and are diluted for use in the packing house. When they are used, they are usually applied ahead of the dryer by atomizing with air, using atomizing jets similar to those used in paint sprayers. This application is commonly followed by passing over a moisture eliminator and then the fruit is dried and polished in the regular manner. In another method, the mixture of paraffin and carnauba wax is sprayed on the fruit by means of a steam jet and this is usually applied following the dryer and the fruit is then polished in a hot polisher surrounded by a steam jacket to maintain the temperature. After it leaves the hot polisher it proceeds over a cool polisher and thence to the grading table. In another method, the wax is dissolved in a highly volatile solvent, usually mineral spirits, and this solution is atomized onto the fruit, the solvent then evaporates, leaving the wax on the fruit. The applicator for this purpose is used at the end of the polisher and just before the fruit goes to the grading table. The function of these waxes is to enhance the polish of the fruit and to reduce the amount of moisture lost in the



BULK LOADING FLORIDA GRAPEFRUIT FOR PROCESSING PLANT

period between packing and consumption of the fruit. Since washing with soap removes much of the natural wax and thus increases the rate of moisture loss from the fruit, waxing is of considerable importance in maintaining the fruit in good condition.

After fruit has been "color-added," it must be so stamped and this is usually done by a stamping machine ahead of the grading table, but stamping machines may also be used after the fruit has left the grading table. As the fruit passes over the grading table, it moves on a roller conveyor which turns the fruit over.

The fruit is here graded according to the outward appearance of the fruit. Injured fruit which is unfit for canning purposes due to decay or extreme injury is dropped into the cull chute by the graders and low-grade sound fruit which is to go to the cannery rather than the fresh fruit market is placed on the cannery conveyor which carries it out to the loading bin. The remaining

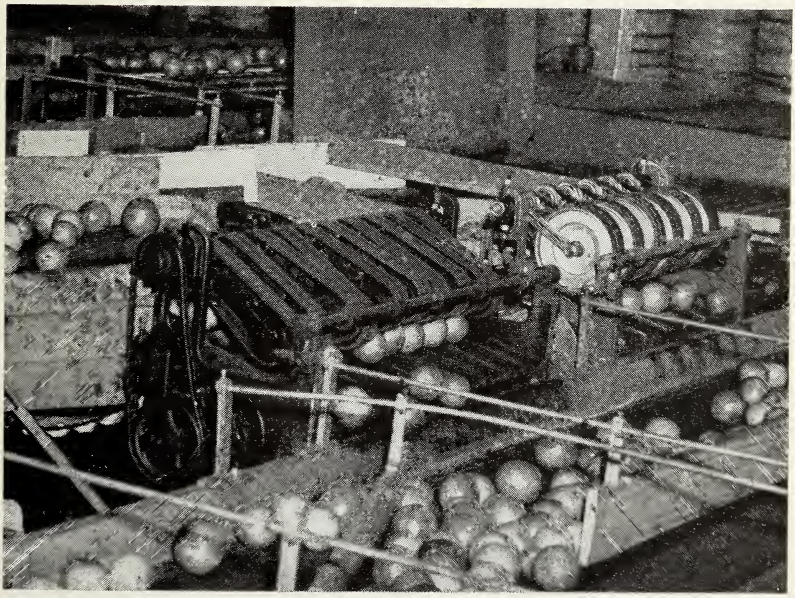


Fig. 67.—Two types fruit stamping machines which may be used to stamp "Color-Added" on the fruit or a trade-mark. All color-added fruit must be so stamped.

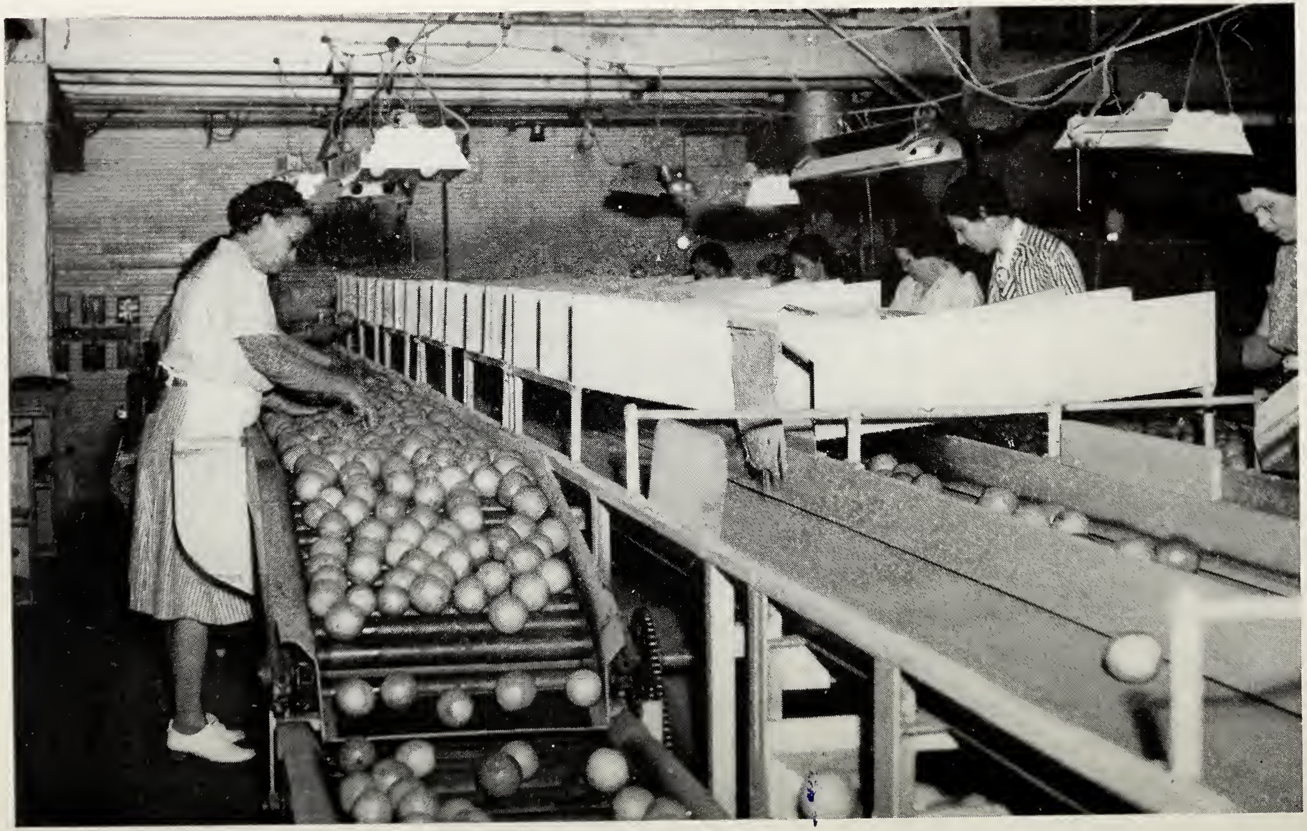


Fig. 68.—Grading table where fruit is graded according to its appearance.

fruit is separated or is graded according to its outside appearance.

Fruit is now classified as US No. 1, US No. 2 and US No. 3 or Florida No. 3. The grade now shipped mostly is US No. 1. In former years, a US Combination grade was used which was the prevailing top grade but has now ~~been eliminated from~~ grades. These grades are based on external characteristics.

There are also optional grades, Grade "A" or Grade "AA" juice, that are based on internal qualities.

Copies of the current grade specifications can be obtained from the State Department of Agriculture office in Winter Haven, Florida.

Grading is usually done by women who have had a great deal of experience and training in this operation.

While the grade descriptions are rather technical and hard for the layman to follow, there is considerable interest in what factors cause grade lowering. The following is a list of grade "lowering" factors in the order of their importance:

Grade Lowering Factors

Type of Injury	*Approx. % of Fruit Affected*
Wind injury	30
Melanose	20
Misc. (field injury, mech. injury, breakdown, creasing, sunburn, sprayburn)	20
Scale	15
Off color (mostly green)	10
Rust mite	5

This listing varies somewhat from previous lists because of changes both in knowledge and practice. Wind damage is now listed as a major factor due to the fact that it is now better known and the markings are no longer

TABLE XI—MAXIMUM AND MINIMUM DIAMETERS OF FRUITS IN VARIOUS SIZES OF ORANGES AND GRAPEFRUIT

Pack	*Diameter in Inches* *Minimum*	*Maximum*
	ORANGES	
96's	3 6/16	3 11/16
126's	3 3/16	3 8/16
150's	3	3 4/16
176's	2 14/16	3 2/16
200's	2 12/16	3
216's	2 10/16	2 14/16
250's	2 8/16	2 12/16
288's	2 6/16	2 10/16
324's	2 4/16	2 8/16
	GRAPEFRUIT	
36's	5	5 9/16
46's	4 11/16	5 2/16
54's	4 6/16	4 13/16
64's	4 3/16	4 9/16
70's	3 15/16	4 5/16
80's	3 12/16	4 2/16
96's	3 9/16	3 15/16
112's	3 7/16	3 13/16
126's	3 5/16	3 11/16

blamed on thrips. Scale have also ascended in the list due to more favorable conditions for their development and melanose and scab are less important due to better spraying.

After the fruit leaves the grading table, it moves by distribution belts to the sizers, where it is carried along on a belt set at an angle so that the fruit is kept in contact with a series of longitudinal rolls. The spacing between the rolls and the belt is varied from close, at the end of the sizer where the fruit enters, to wide, at the far end of the sizer, so that the fruit is separated into a series of sizes by dropping between the belt and the rotating rolls.

The sizes are determined and designated by the number required to fill the standard box, thus you have in oranges, 126's, 150's, 176's, 200's, 216's, 250's, 288's and 324's. The designations indicate the number of fruits of that size which can be packed into a standard box following a prescribed pattern. These patterns will not be given here because the standard box is so little used at the present time. The diameters of fruit in inches for the various sizes, however, are given in Table XI. In grapefruit, the sizes are naturally larger, and the common sizes are 36's, 46's, 54's, 64's, 70's, 80's, 96's and 126's. In recent years there has been a tendency, in both oranges and grapefruit, to send very small and very large sizes to the cannery and send only the middle sizes to the fresh fruit market, the sizes shipped depending to a considerable extent on the market demands, and also being subject to control by the Growers Administrative Committee.

As the fruit falls through the sizer, it is retained in bins for each individual size and the fruit is packed into boxes by professional packers, each box containing fruit of only one size. The box formerly used contained 1-3/5 bushels and had a center partition. The fruit was packed into it in a regular pattern for each size, and the box was filled two or three inches above the top of the box. The lid was then put in place and the ends pulled down in a lidding machine, after which the lid was nailed and strapped. This resulted in a bulge, which helped to keep the pack tight. The standard box now is used for

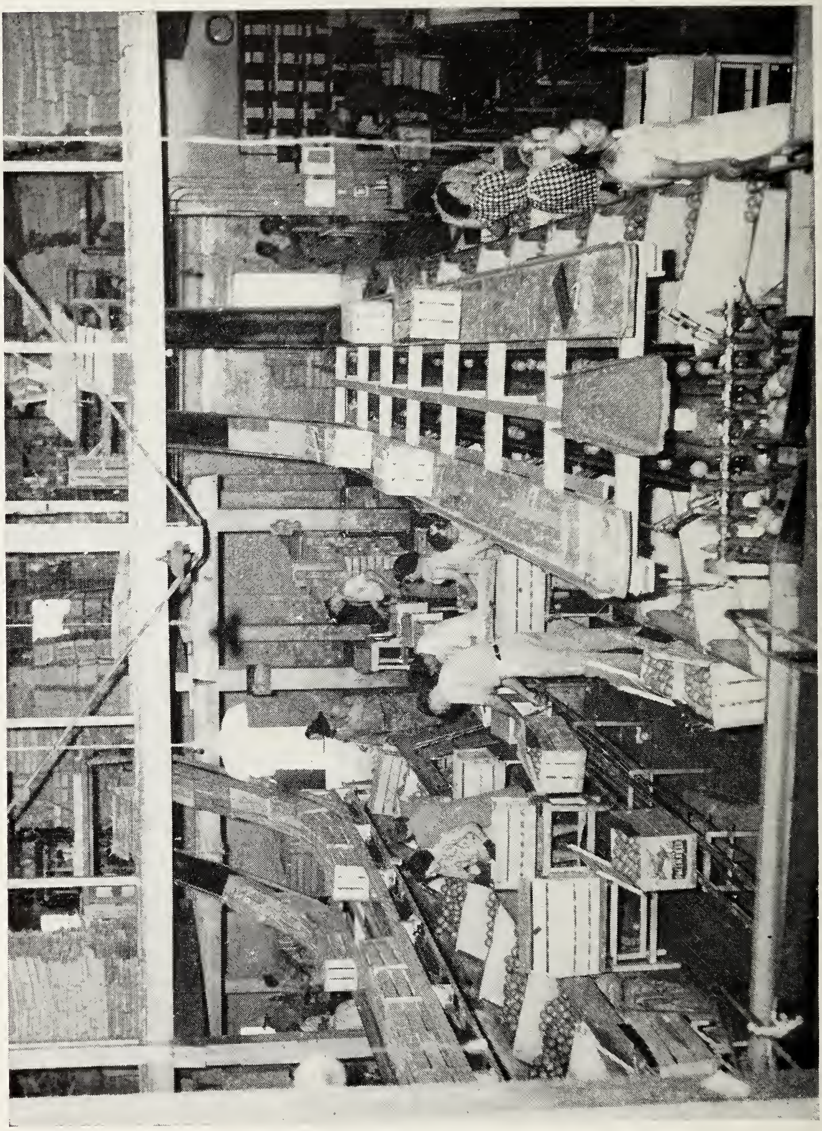


Fig. 69.—Sizers in packing house.

only a relatively small proportion of the crop and is usually utilized for the fancier grades that bring better prices. Fruit put in the standard boxes is usually wrapped individually in tissue paper wraps, although in later years, there has been a tendency to do what is known as "face wrapping," in which the fruits on the top layer and the fruits facing the cracks are wrapped and the fruits in the center of the box are left unwrapped.

In the last few years, the so-called wirebound crate has largely substituted for the standard box. It likewise contains 1-3/5 bushels, and is bound with wire instead of being nailed together. The crates come knocked down from the crate manufacturer and are easily assembled in the packing house with the aid of a simple wire bender. Standard boxes on the other hand, had to be nailed together in the packing house either by hand or with the use of elaborate nailing machines. The fruit is put into the wirebound box, which does not contain a center partition, in layers and not in a standard pattern, but the numbers of fruits per box correspond to the designations for the standard box. Fruit is practically never wrapped when packed in wirebound containers and the cost of the container is lower than that of the standard box, the cost of wrapping and packing is reduced, and the cost of closing the container (see Fig. 71) is cheaper than the cost of lidding boxes of the standard type, which had to be done by an expert nailer.

After the fruit is packed, the packer stamps the grade and size on the box and the fruit is carried away from the nailer's stand and stacked according to size and grade. From there it is moved to a refrigerator car by hand truck and stacked into the car according to a regular system. Standard boxes are stacked on end and cleated in place and wirebound containers are stacked on their sides. Prior to the war, it was customary to stack wirebound containers four high, and in the standard car this results in about 440 boxes per car, the number varying with the size of the car. Since the war has brought on a shortage

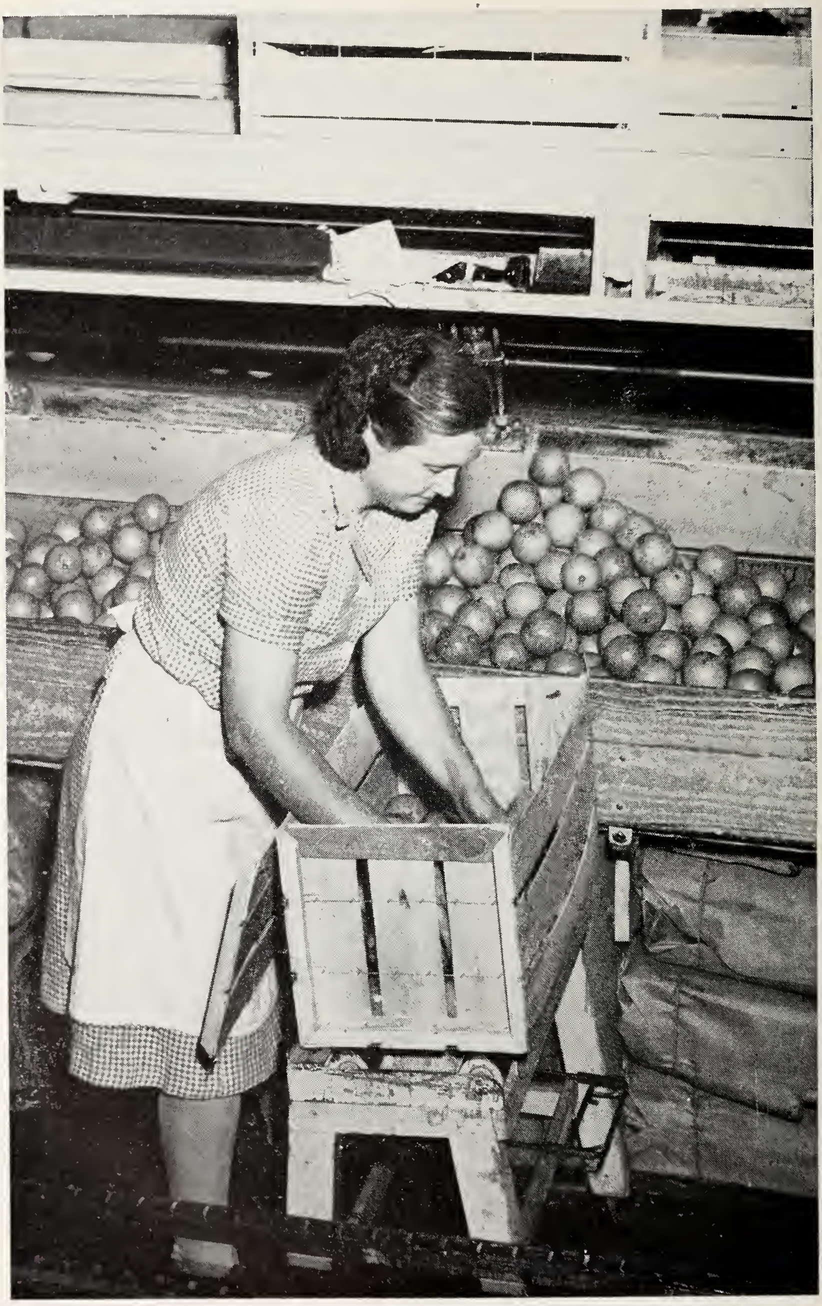


Fig. 70.—Packing fruit in wirebound container. Fruit is packed in layers and not in a regular pattern as in the standard box.

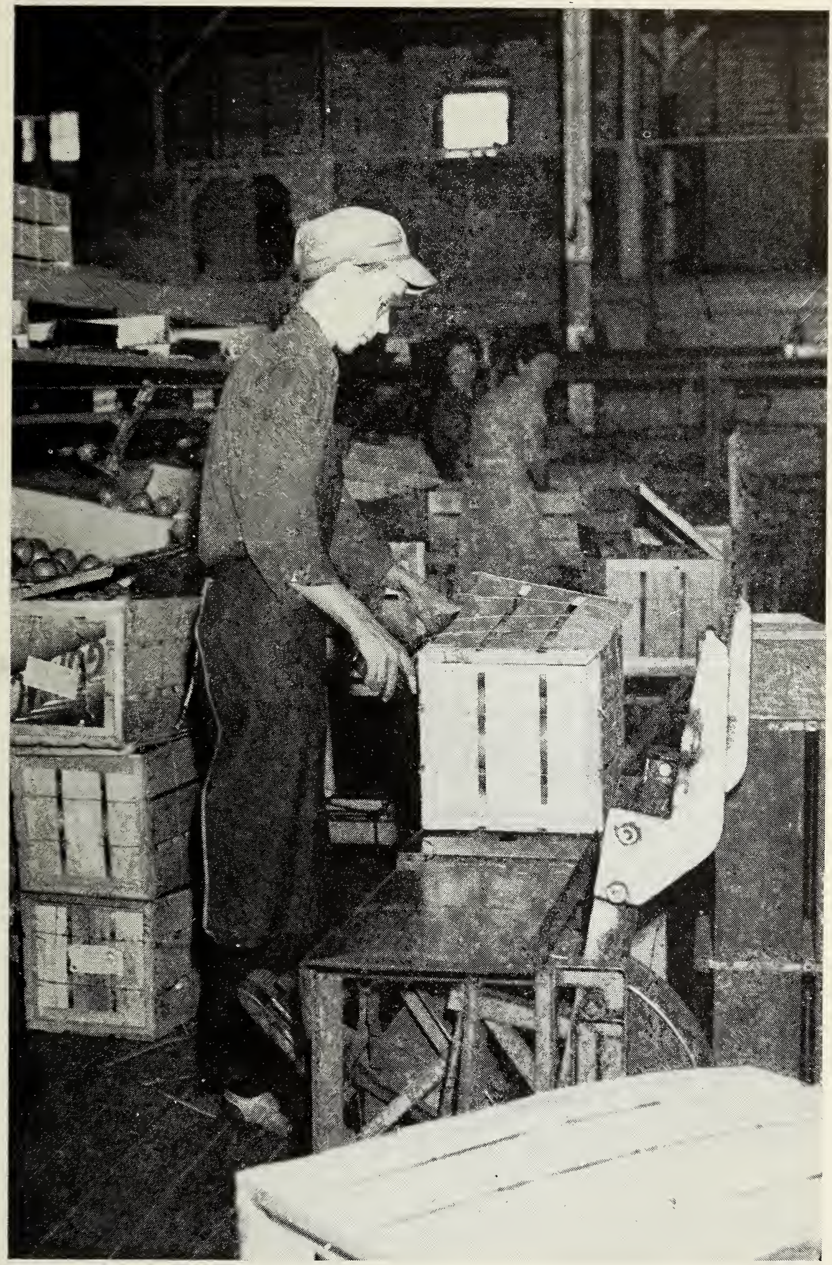


Fig. 71.—Closing wirebound container.

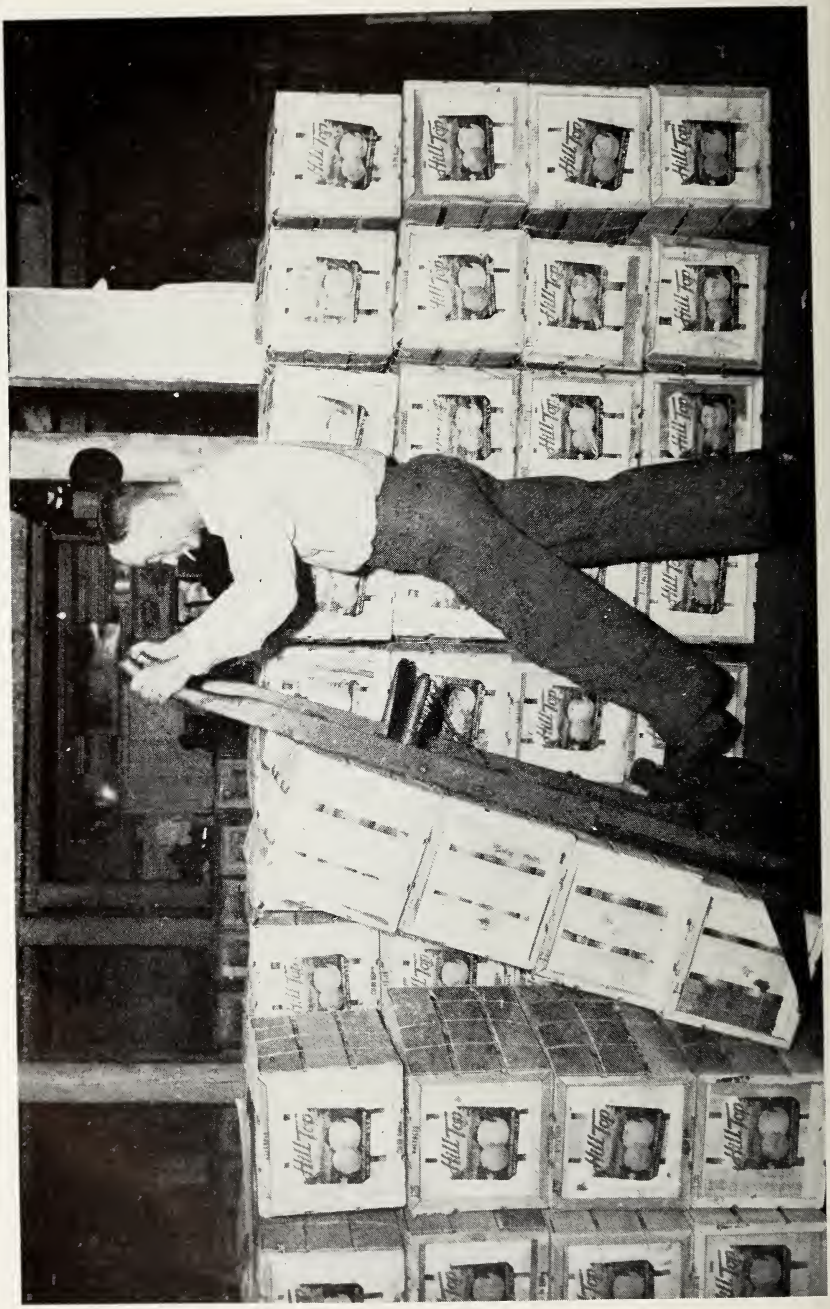


Fig. 72.—Stacking fruit by grade and size after it is packed.

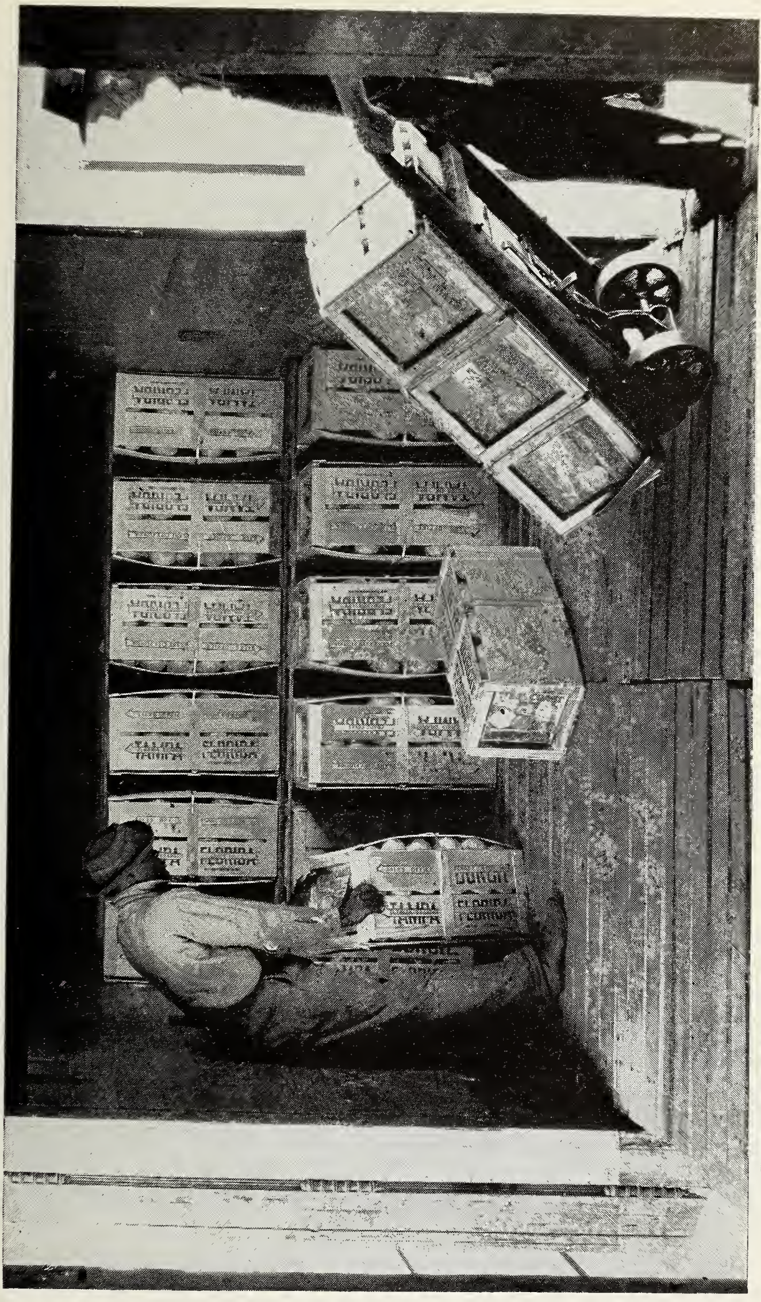


Fig. 73.—Packing fruit in standard boxes in a refrigerator car. Note stripping to hold boxes in place.

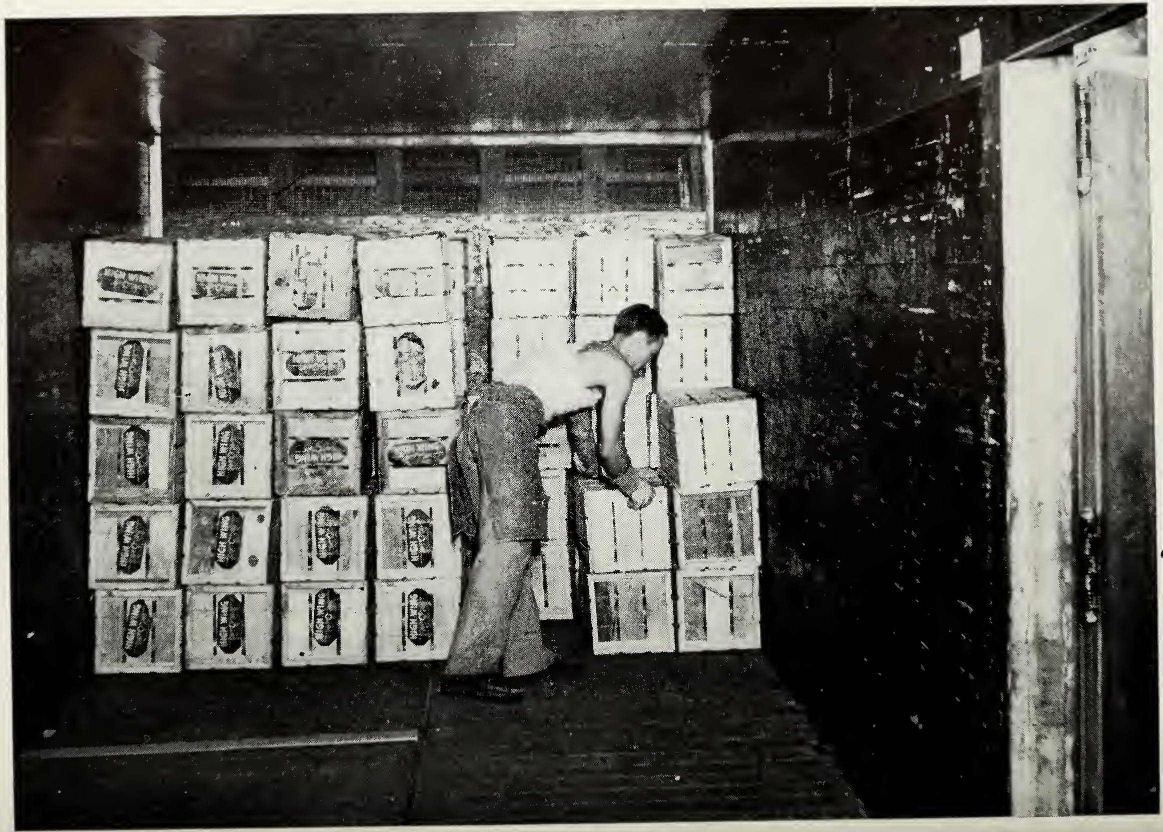


Fig. 74.—Stacking wirebound containers in a refrigerator car. These are not stripped and bulkheaded as are standard boxes.

of transportation, the stacks are usually five high, as shown in Fig. 74 and cars commonly carry 525 boxes.

Some fruit is moved in cotton mesh bags, but the original large bags have been discarded in favor of 8-pound bags for direct sale to the consumer without repackaging. Larger bags are being tried for grapefruit. This type of packaging is in line with the general trend to prepackaging for consumer sale.

A corrugated paper container has been successfully used during the last few years. This contains the equivalent of one-half box and is coated internally with a decay inhibitor. Experiments are also being conducted on small containers for tangerines.

During warm weather, fruit is commonly precooled before it leaves the packing house, although this practice is not always followed. Some packing houses have large insulated precooling rooms in which the boxes of fruit are stacked four high and cool air is circulated through the room to bring the temperature of the fruit down to 40 or 45 degrees F. After it is cooled, it is stacked in the car and ice put in the car bunkers. In recent years, there has been an extensive use of a refrigerating unit, which can be attached to the door opening of the car or truck after it is filled and cold air circulated through the car to precool the fruit before icing (see Fig. 75). If the weather is cool, the fruit may be shipped under "vents," instead of iced; i.e., the vents are left open and adjusted by the train crew from time to time in accordance with the outside weather. In warm weather, when precooling is used, the vents are kept closed and the bunkers full of ice to keep the fruit cool until it reaches the market. Refrigerator cars are especially made for the purpose of hauling fruit, and have their walls insulated and contain bunkers at each end for ice. The railroad maintains regular icing stations for replenishing the ice supply.

In recent years a considerable business in individual boxes of fruit has developed. In this business, the shipper ships boxes of fruit by express to individaul consumers. A good many small growers and packing houses operate in this business which has become very extensive

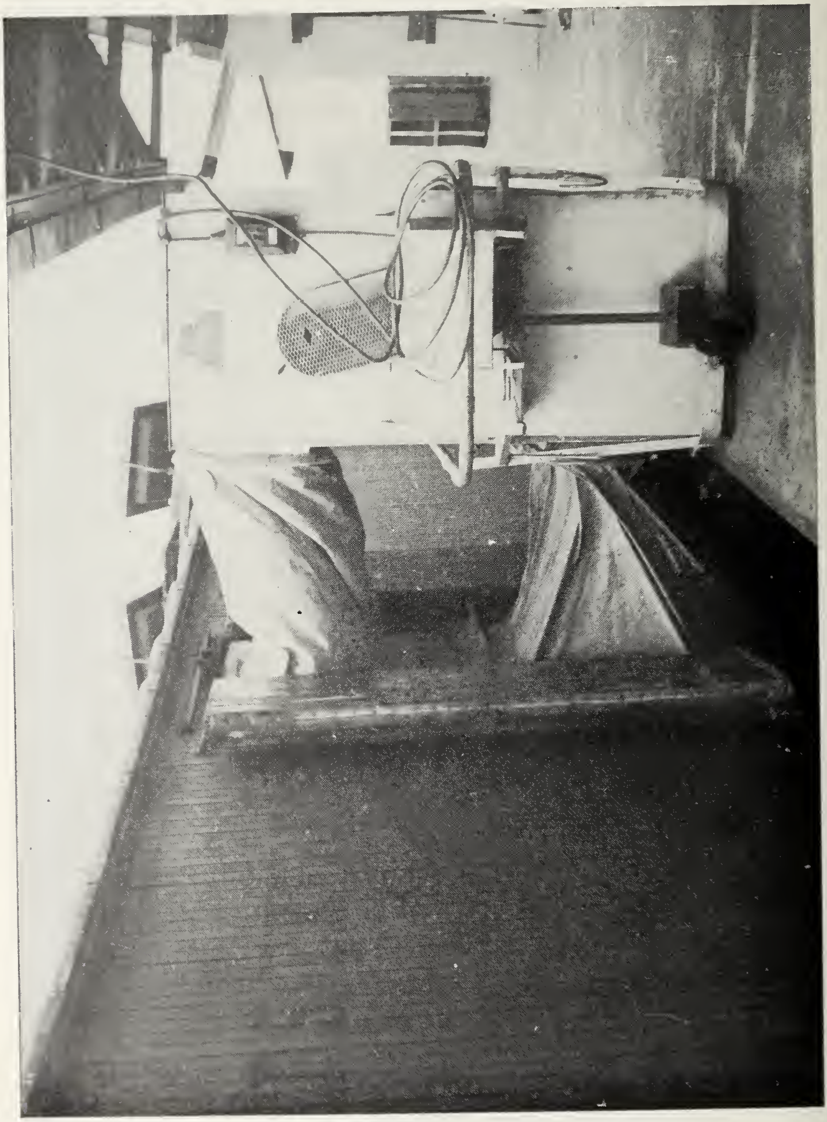


Fig. 75.—Precooling unit circulating cold air in loaded car before icing.

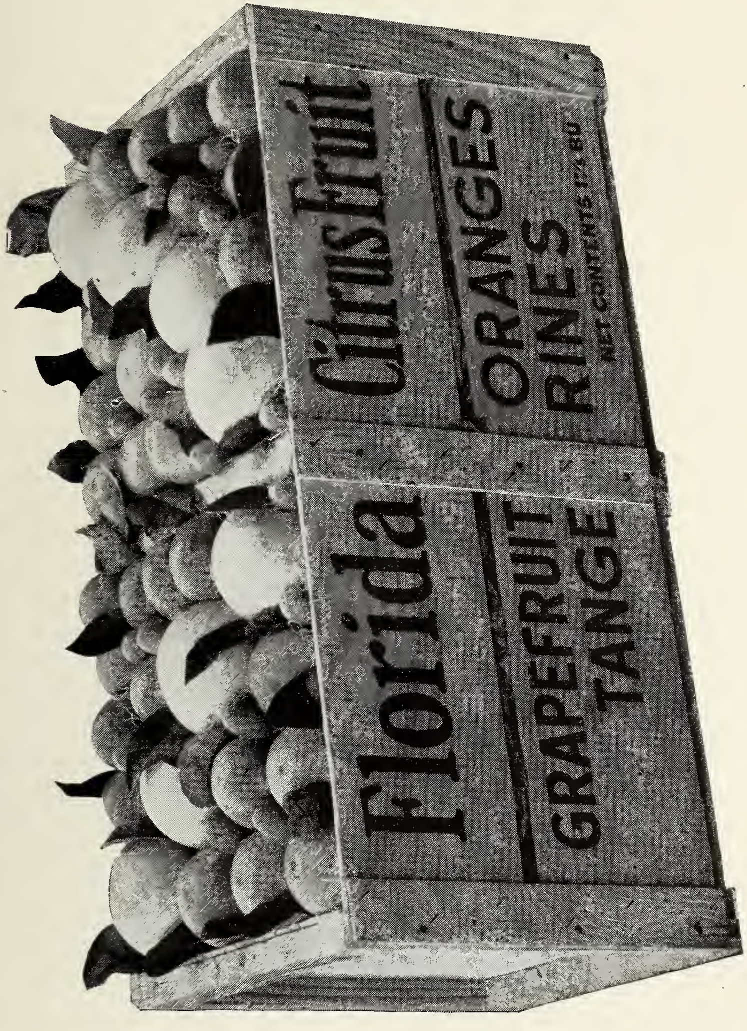


Fig. 76.—A fancy box of mixed citrus fruits ready for the express trade.

and much of this fruit is handled by individual growers with very small packing units. In other cases, the fruit is shipped directly by express to individual customers by large packing houses which maintain a side line for this purpose. There is a heavy demand for such fruit for the Christmas market, and many operators make a specialty of fancy packs containing several different varieties of fruits for this purpose. A picture of one of these fancy packs is shown in Fig. 76.

The packing of citrus fruit is a rather specialized field and this discussion is not intended as a guide for packing house operators, but rather as a guide for newcomers to the state. It is hoped that it may help new growers to better understand the rather complex packing house procedure.

PART III

CITRUS MARKETING

By

ROBERT C. EVANS
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Limitation and Rules on Shipments

There are two principal regulatory bodies in the state concerned with rules and regulations governing the shipment of citrus fruits. They are the Florida Citrus Commission, a state agency, and the Growers Administrative and Shippers Advisory Committees, operating under the Federal Marketing Agreement Act. The activities of both of these bodies are directed by growers and shippers in the citrus industry.

The Florida Citrus Commission was established in 1935 under a special act of the Florida Legislature, and has been in operation continuously since that time. The Commission consists of twelve growers and five of these members must also have connections with shippers, processors and concentrators. The Commission is therefore representative of all phases of the industry. The powers and duties of the Commission relating to citrus marketing include the following:

1. Promulgation of rules and regulations for the handling of citrus fruits. The principal regulations relate to the following activities:
    - (a) Maturity tests for citrus fruits.
    - (b) Grade standards for citrus fruits.
    - (c) Forms and instructions for issuance of certificates of inspection.
    - (d) Approval of license applications of citrus dealers.
    - (e) Method of payment of inspection fees.
    - (f) Artificial coloring of fruits.

(g) Coloring room practices.
(h) Adoption and use of citrus containers.
(i) Registration and use of labels.
(j) Issuance and use of permits.
(k) Tests for fruit damaged by freeze.
(l) Tests to prevent the canning of unwholesome fruit.
(m) Method of making returns for advertising assessments.
(n) Proper filling of containers.

These regulations are promulgated by the Commission and enforced by the State Department of Agriculture.

2. To collect and account for the excise taxes imposed by law upon citrus fruit grown in Florida.
3. To plan and conduct a campaign for commodity advertising, publicity and sales promotion.

The Growers Administrative and Shippers Advisory Committees operate the Federal Marketing Agreement program under which the grades and sizes of fruit that may be shipped in interstate commerce are regulated. The principal purpose of these regulations is to prevent the shipment of low grades and undesirable sizes of fruit in interstate commerce. The regulations are changed from time to time as conditions warrant. The committees each consist of eight members, all growers and shippers, who are appointed by the Secretary of Agriculture, U. S. Department of Agriculture, Washington, D. C.

Sales of Fruit by Growers

There are three principal methods used by growers in selling their fruit. They are (1) sales through cooperative marketing associations of growers, (2) "on tree" sales to shippers and processors, and (3) consignment sales. In the 1951-'52 season 45 percent of Florida's citrus production was shipped in fresh form and the balance utilized by canners and concentrators.

In the year 1951-'52 approximately 40 percent of the fruit shipped in fresh form was handled by cooperative marketing organizations. There are a number of such organizations in the industry and their operations extend over the entire citrus belt. Most of the balance of the fruit is sold by growers to shippers and canners at a fixed price per box or on a bulk basis. In practically all instances the buyer is responsible for harvesting and hauling the fruit to the packing plant. In some instances, growers enter into contracts with shippers to handle their fruit on consignment basis. Under this arrangement the shipper sells the fruit for the growers' account and returns all proceeds to the growers after deducting handling charges specified in the consignment contract.

In some cases, growers pack, ship and sell their own fruit. They perform all of the functions of a shipper and must obtain a license as a citrus fruit dealer and comply with all rules and regulations applicable to shippers.

Sales of Fruit by Shippers

The two principal methods employed by shippers in selling fresh citrus fruits are f.o.b. shipping point sales and auction sales. Some shippers sell practically all of their fruit through the auctions in the terminal markets, while others sell little or none by this method. This latter group prefers to sell on an f.o.b. or some other basis The principal auction markets are located at Baltimore, Philadelphia, New York, Boston, Pittsburgh, Cleveland, Cincinnati, Detroit, Chicago and St. Louis. The shippers who sell at auction have representatives in the auction markets to arrange for the fruit to be listed with the auction company for sale. These representatives attend the auction sale, and otherwise represent the interests of the shipper. Some of the larger shippers maintain salaried employees in the auction markets to handle their auction and other sales. However, most of the shippers arrange for such representation by brokers and auction receivers.

Most of the f.o.b. shipping point sales are handled through brokers or salaried representatives of shippers.

There are several other methods of sale, such as "consignment" ~~and "delivered"~~ sales. The former involves shipping fruit to commission merchants and jobbers to sell the fruit for the account of the shipper on a specified commission or fee basis. In the latter type of sale the shipper offers the fruit to buyers at a price f.o.b. the point of delivery and assumes all freight charges and transportation risks.

Transportation of Fruit

Citrus fruit sold in fresh form is shipped by rail, truck and boat. Boat service was suspended during the war and has not yet been resumed on a volume basis comparable with pre-war years. Likewise, truck shipments were greatly reduced during the war years, but have now become tremendously important. During the 1940-'41 season, the last season before the United States entered the war, 46,651 cars of Florida fresh citrus fruits were shipped by rail, 17,615 cars by boat, and 18,935 by truck. In the 1951-'52 season 56,998 cars were shipped by rail, 41,801 cars by truck, with very negligible shipments by boat.

PART IV

CITRUS PROCESSING

By

L. G. MacDowell
Director of Research

Florida Citrus Commission, Lakeland, Florida

Since its inception in the early 1920's, the citrus processing industry in Florida has made rapid growth. The importance of this portion of the Florida citrus industry is emphasized by the fact that during the past season (1951-'52), 60.4% of the orange crop, 38% of the grapefruit crop and 15% of the tangerine crop was processed. This processed portion of the crop amounted to approximately 62,000,000 boxes (1-3/5 bushels capacity), or about 2,750,000 tons.

During the 1952-'53 season, 41 processing plants operated in the state. The geographical distribution of these plants by counties follows: Polk, 17; Orange, 7; Hillsborough, 5; Lake and Manatee, 2 each; DeSoto, Pinellas, Pasco, Volusia, St. Lucie, Osceola, Marion and Hardee, 1 each.

The products produced by these plants are canned single-strength citrus juices, canned citrus segments, frozen concentrated citrus juices and pasteurized concentrates.

GRAPEFRUIT JUICE, ORANGE JUICE, TANGERINE JUICE AND BLENDED JUICE: For many years the canning of citrus juices was regarded as a method of disposing of fruit which was not preferred for fresh fruit shipment. This canning grade fruit, while equal in internal quality to the fruit shipped, suffered from skin blemishes, irregular sizes, etc. In more recent years, however, the demand for canned citrus products has become so great that a large precentage of grove-run fruit is now being used for canning purposes. In fact, whole crops are being grown solely for the canning plant.

For grapefruit juice, the seedy grapefruit enjoys a preference because of the higher solids content of its juice. However, a substantial quantity of seedless grapefruit is also used. All varieties of oranges are used for canning purposes, but the mid-season and Valencia varieties are preferred. The Dancy is the only commercial tangerine in Florida.

Canned Juices: Oranges, grapefruit and tangerines to be used for canning purposes arrive at the canning plant by truck or rail in bulk quantities. They are then transferred to elevated, ventilated storage bins capable of holding large quantities. Going into the canning plant proper the fruit is washed, graded and thoroughly inspected. Any unwholesome fruit is removed in the grading process. State law provides severe penalties for the use of unwholesome fruit and this law is enforced by the presence of a State Inspector in each canning plant.

After washing, grading and inspection the fruit is automatically sliced and extracted. The juice is then screened to remove seeds and pieces of pulp. Following screening, the juice is de-aerated under vacuum and pasteurized. The de-aeration step insures the maximum preservation of flavor and vitamin C. After pasteurization the juice is automatically filled into sterile cans and the canned juice is quickly cooled to room temperature and placed in storage. Sweetened juice is obtained by adding appropriate quantities of sugar to the juice before it is canned. Blended juice is a mixture of grapefruit and orange juice which usually contains from 40% to 60% grapefruit juice and 60% to 40% orange juice.

Grapefruit Sections and Citrus Salad: Oranges and grapefruit to be used for sections are treated somewhat differently from fruit used for juice. After washing and grading the fruit is immersed in hot water for a few minutes. This treatment plumps and loosens the skin without heating the inside of the fruit. The fruit is peeled by hand and placed in baskets. The baskets of peeled fruit are then immersed in an alkaline bath which removes the outer membranes covering the juice sacs. The alkali is washed off by sprays of fresh water and the sections are removed by hand with a triangular bladed knife. The utmost care is taken not to break the sections as the operator is paid on the piece basis. The sections are finally packed in cans to which sugar syrup has already been added. The cans are finally sealed, sterilized, cooled and stored away.

Citrus salad consists of grapefruit and orange sections packed in the same can, and is not only very tasty but also very pleasing to the eye.

FROZEN CONCENTRATED CITRUS JUICES: Frozen concentrated orange juice has experienced a most phenomenal growth. From a beginning of 226,000 gallons produced in 1945-'46, the production of this "Cinderella" product has grown to over 44,000,000 gallons in the 1951-'52 season. Frozen concentrated grapefruit juice, frozen concentrated blended orange-grapefruit juice and frozen concentrated tangerine juice are also made.

Only the finest oranges are used in frozen concentrate and a large proportion of them move directly from the grove to the concentrating plant. Here they are carefully washed, sorted, sterilized and analyzed for uniformity. After the juice is extracted, the major portion of it is evaporated in vacuum at temperatures ranging from 60°F. to 80°F. until a soluble solids content of about 55% is reached. The concentrated juice is then transferred to refrigerated blending tanks where enough freshly extracted juice is added to lower its concentration to 42% soluble solids. This "cutback" principle restores volatile flavoring materials partially lost during evaporation and allows the easy re-introduction of the pulpy juice cells. It also facilitates the control of concentration of the finished product.

The finished product is slush frozen, filled into cans, sharp frozen and finally stored in warehouses at —10° F.

Frozen concentrated orange juice as it appears on the market today is strictly regulated by laws of the State

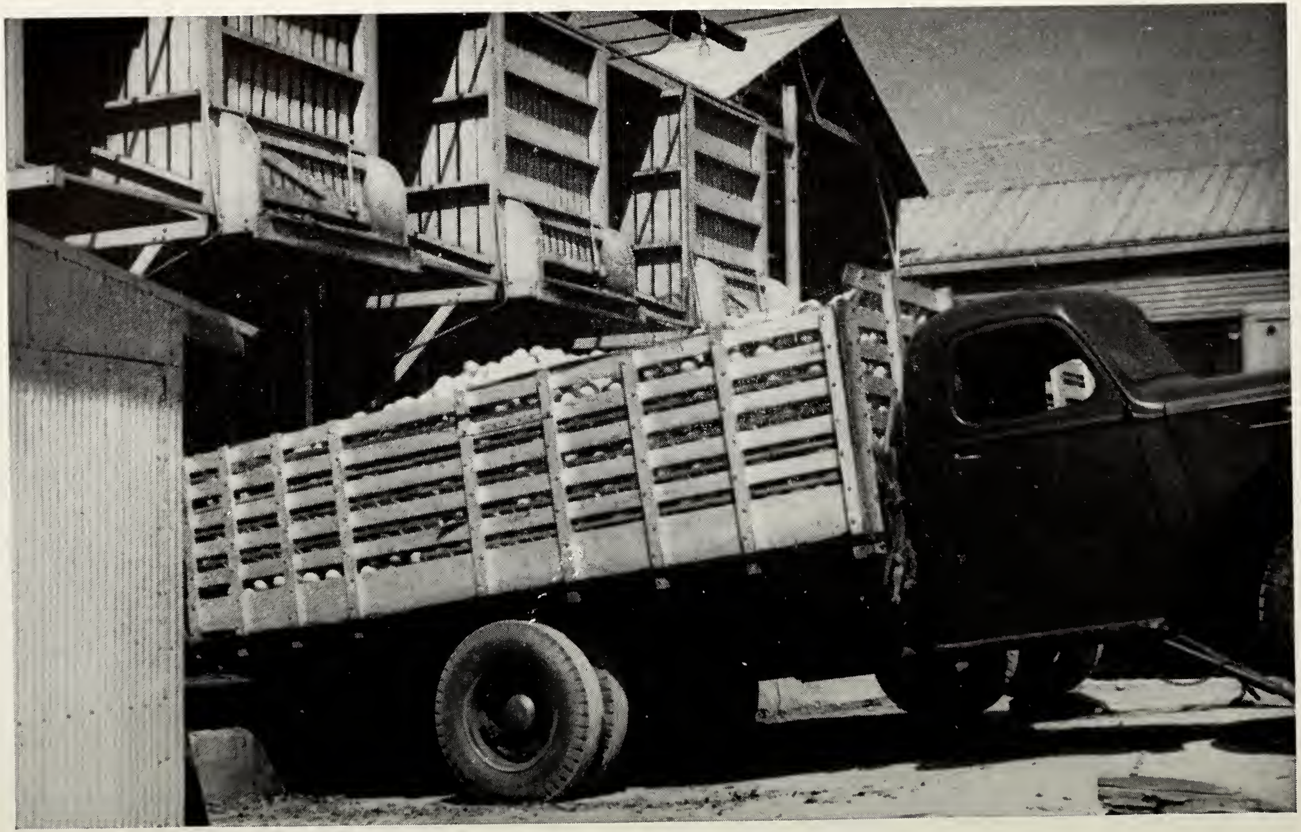

Fig. 77.—Unloading bulk citrus fruit at cannery. The fruit flows by gravity from the truck onto a conveyor which carries it to the bins.

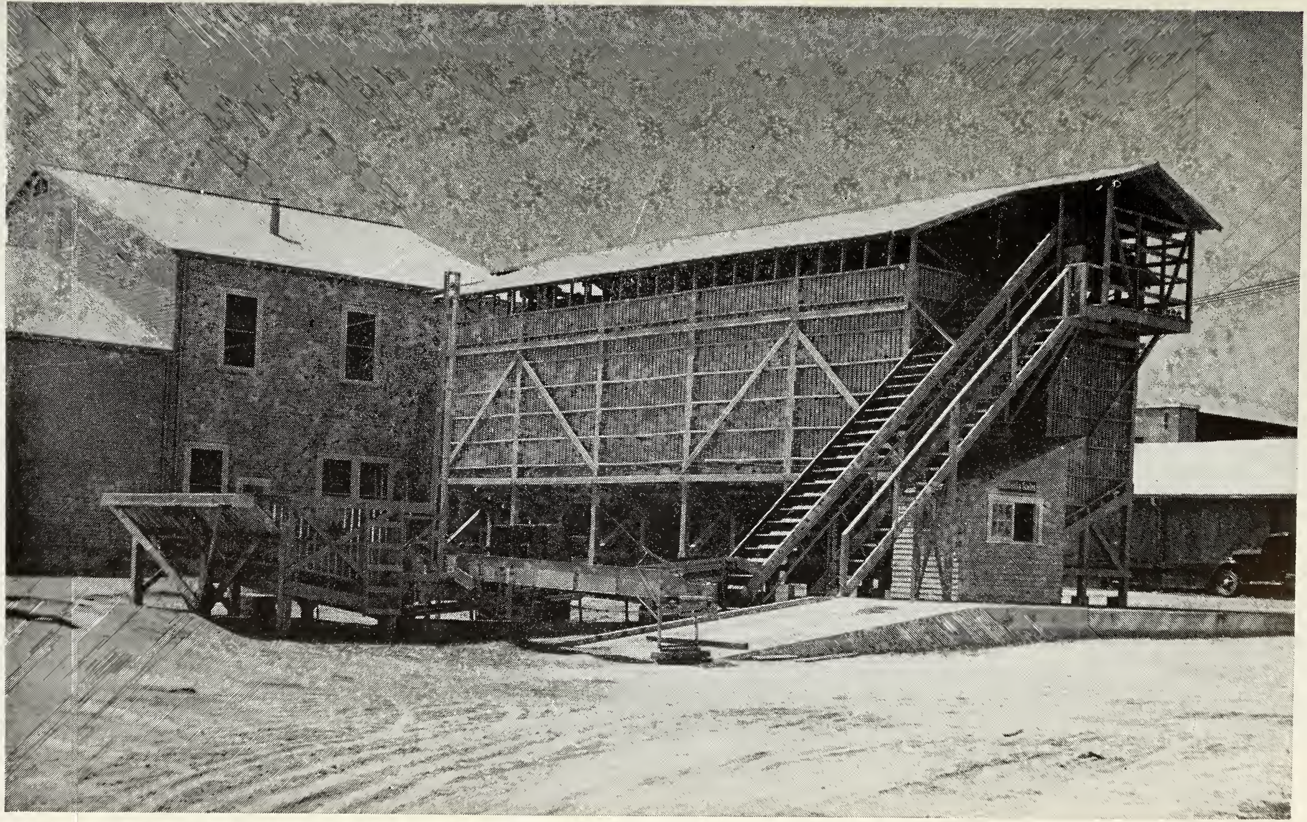

Fig. 78.—Storage bins for fruit at citrus canning plant. Fruit is carried from bins into the plant by conveyors.

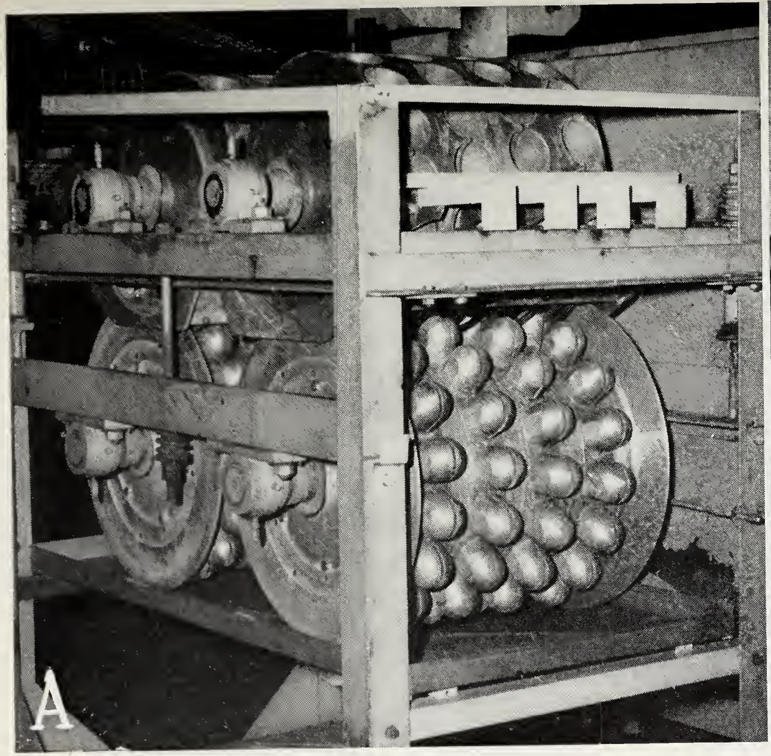

Fig. 79a.—Side-angle view of rotary juice extractor. The juice is expressed from the halved fruit by the inverted cups protruding from the lower drums.

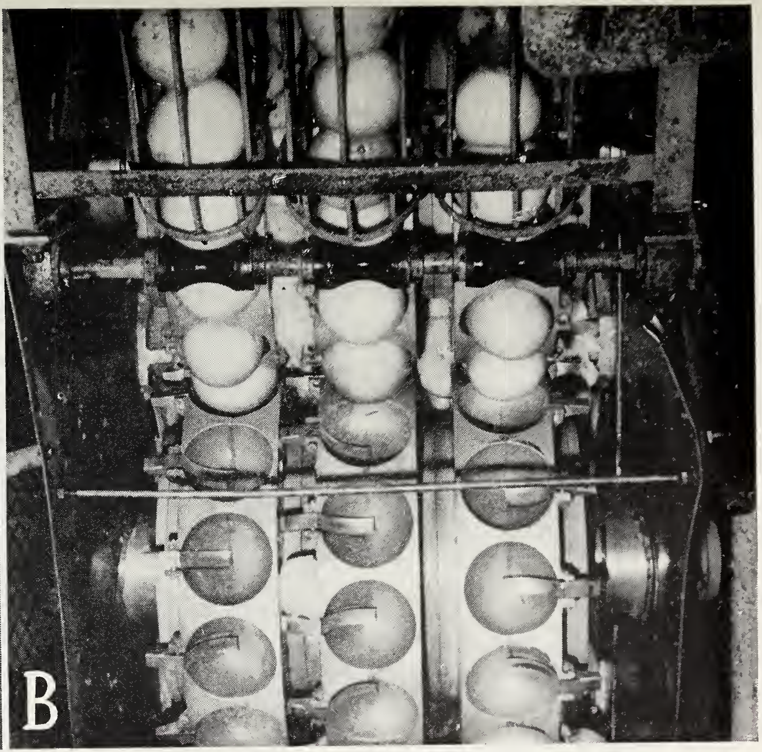

Fig. 79b.—Juice Press. Top view of rotary juice extractor for oranges and grapefruit, showing fruit dropping into the cups. As it is carried downward it is cut in half by a sanitary knife.

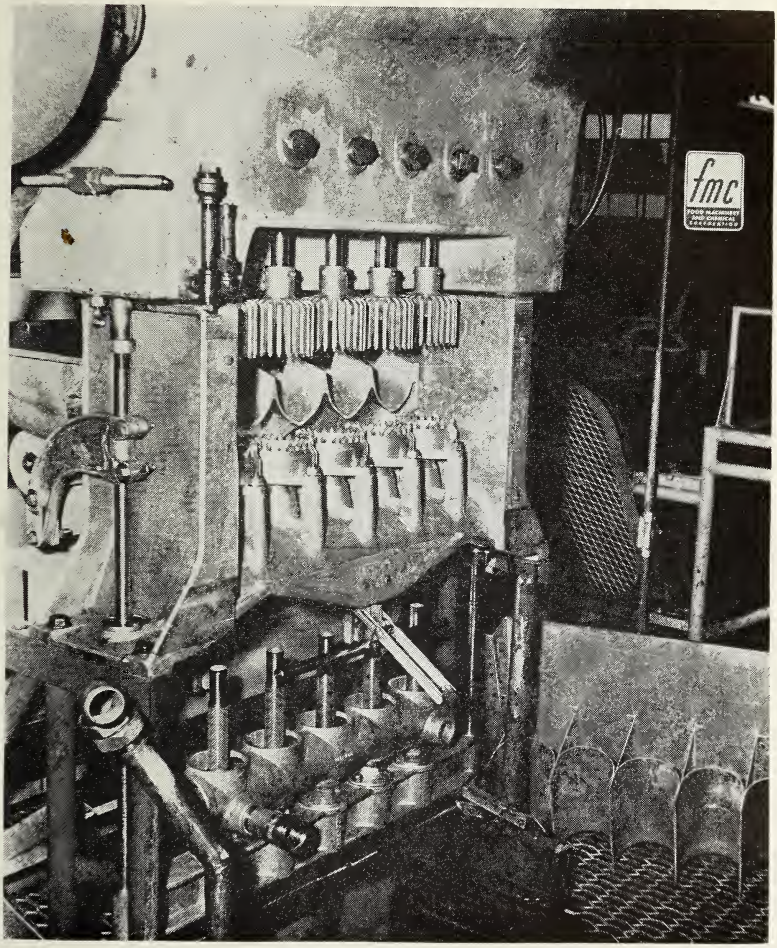

Fig. 80.—In-line juice press with cover removed and manifold lowered.

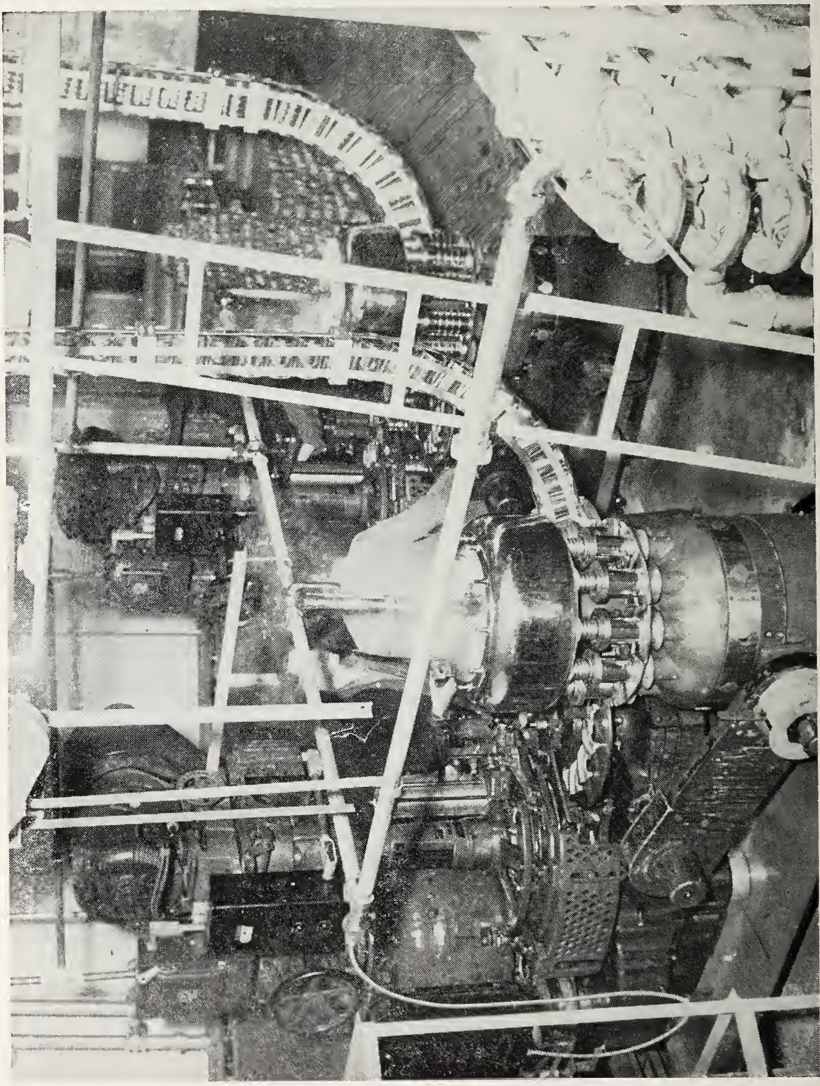

Fig. 81.—Filling and capping cans in citrus juice plant.

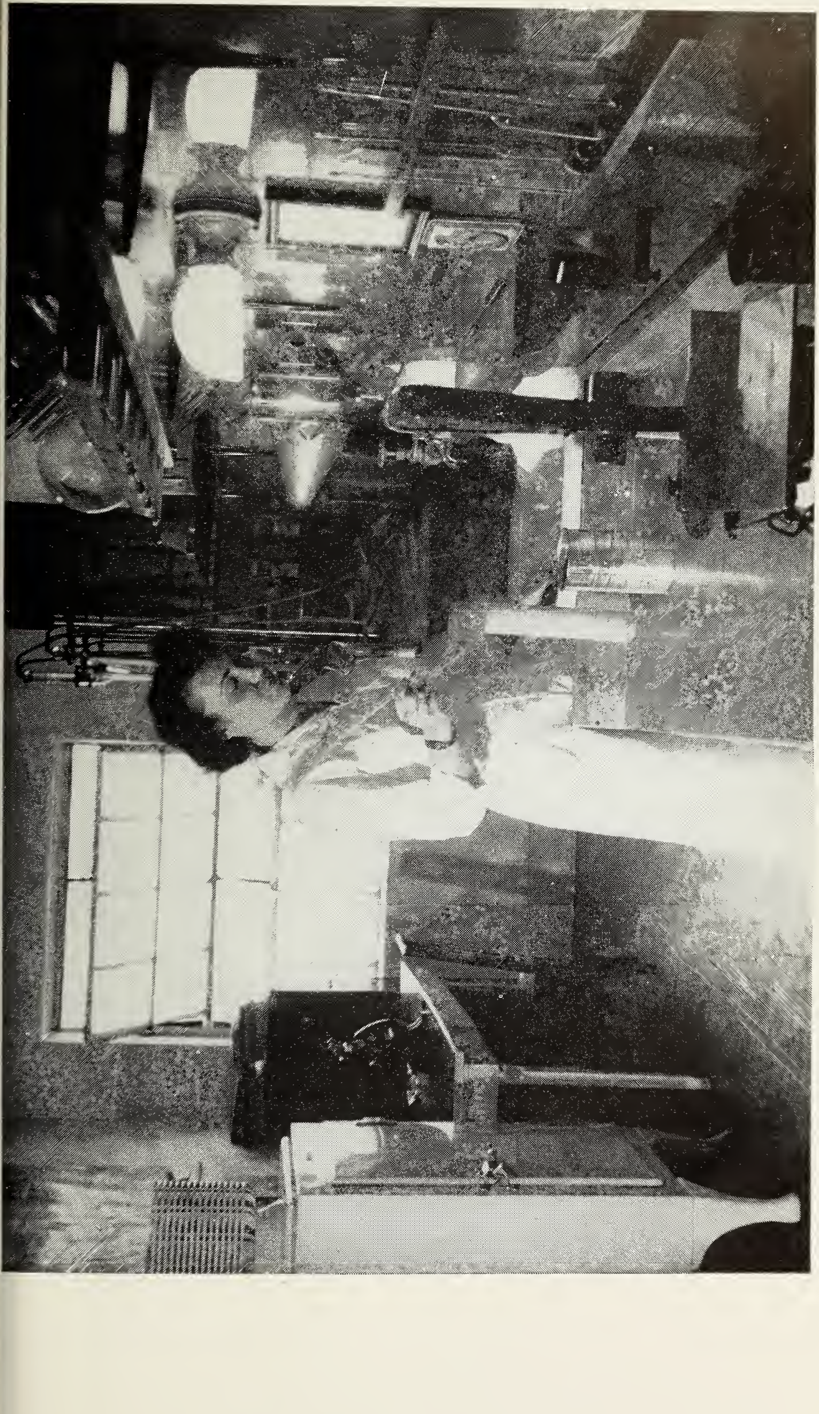

Fig. 82.—The quality of canned citrus juice is laboratory controlled.

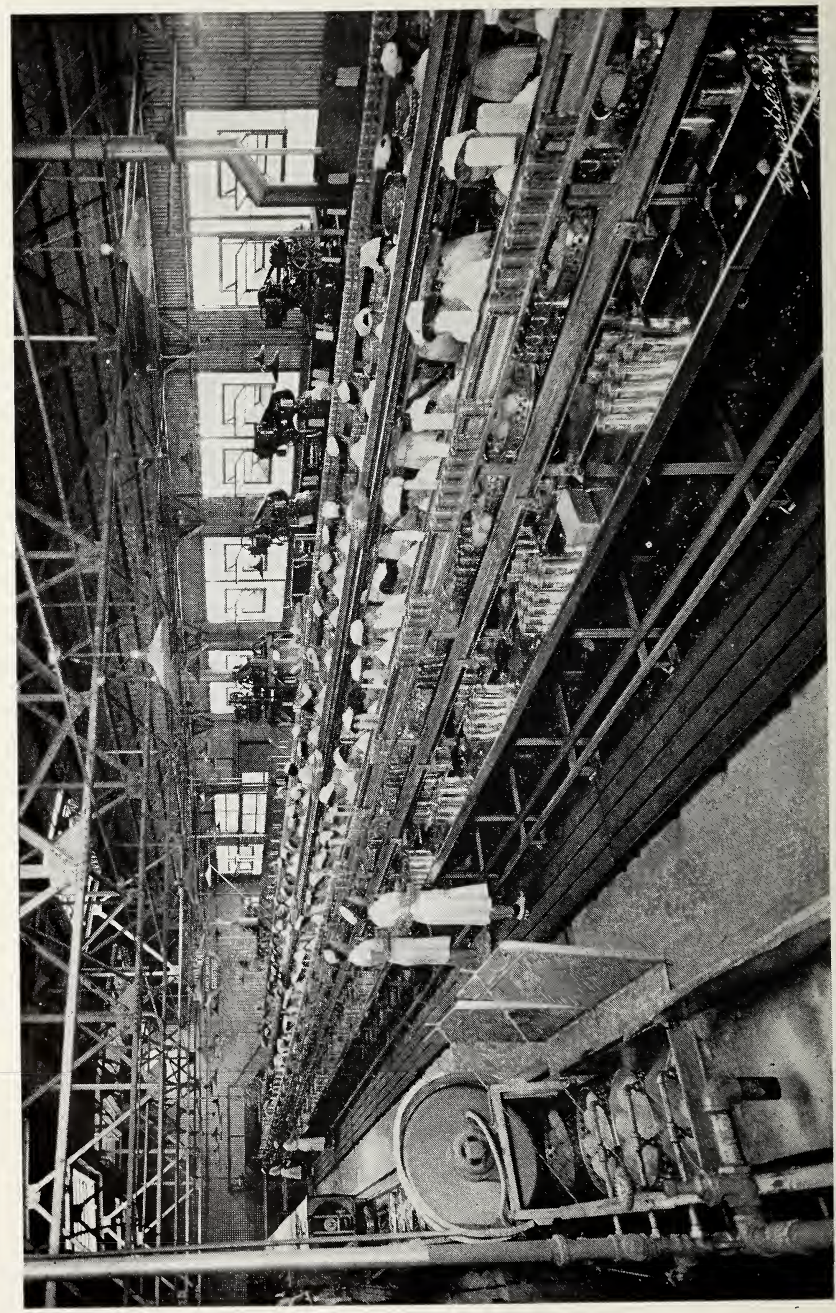

Fig. 83.—Sectionizing tables in grapefruit canning plant.

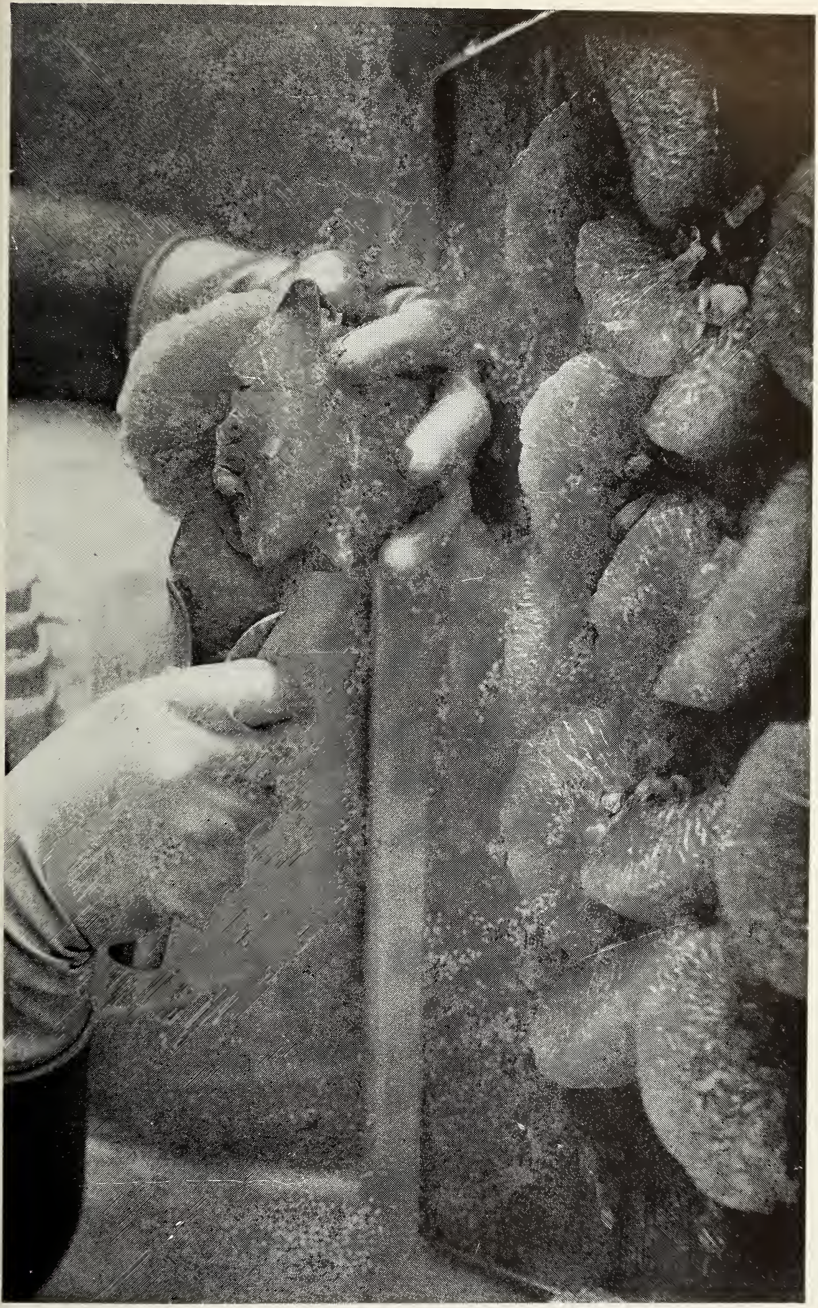

Fig. 84.—Sectionizing grapefruit. All sectionizing is done by hand so that the pulp may be fully separated from the section walls.

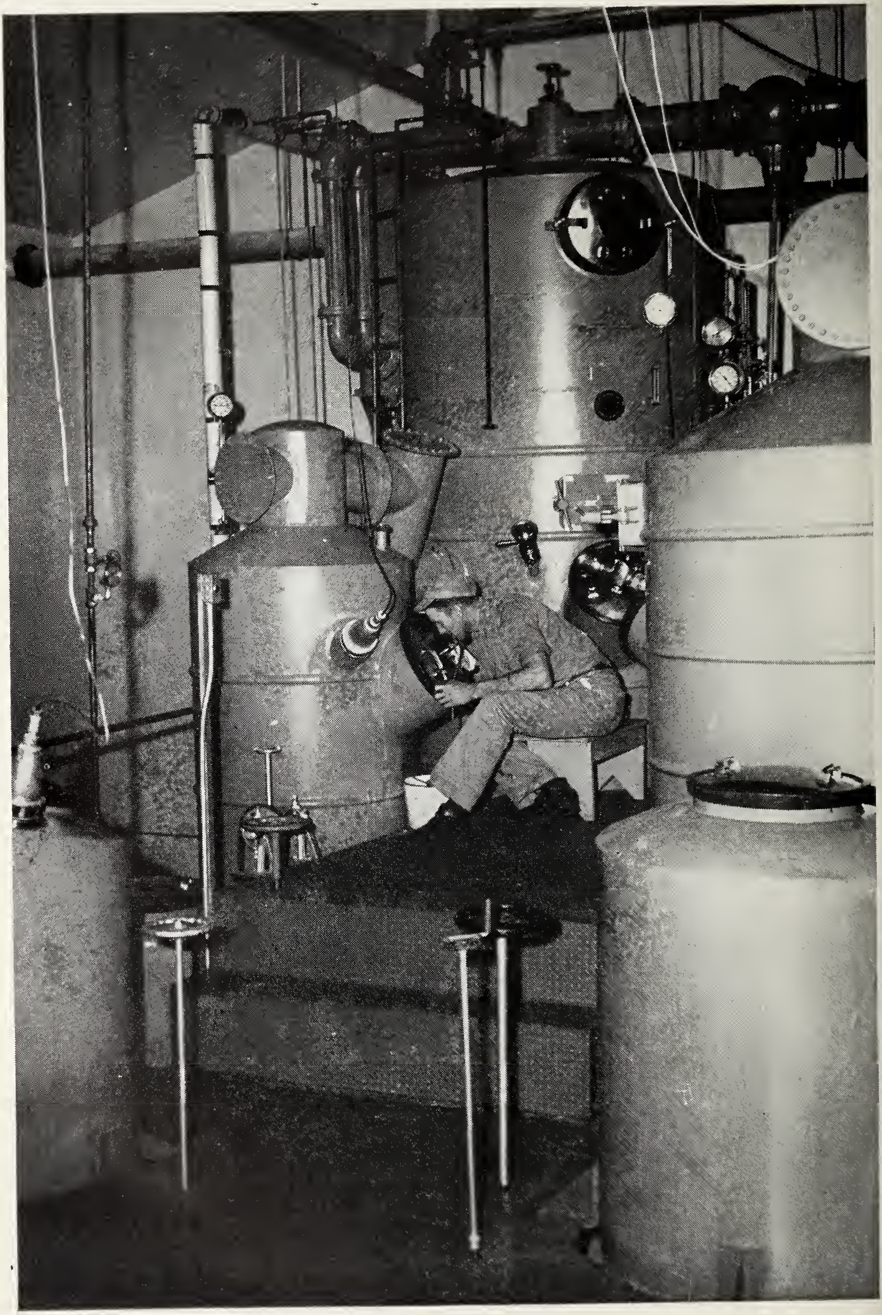

Fig. 85.—Equipment in citrus juice concentrating plant.

of Florida and standards of the Federal government. Its concentration is almost constant at 42% soluble solids, allowing the addition of three parts of water to obtain four parts of full-bodied orange juice, and its range of sweetness falls within narrow limits. By law, nothing can be added to frozen concentrated orange juice produced in Florida; it is the pure juice of fully ripe oranges with only a portion of its water content removed.

PASTEURIZED CONCENTRATES: Pasteurized concentrates are manufactured in a manner similar to that of the frozen concentrates with the exception that the final product is not frozen but is sufficiently pasteurized to ensure its preservation. To maintain its quality it should be stored at 40°F. or below.

By-Products

STOCK FEEDS: The increasing amount of citrus fruits being canned and concentrated has led to a corresponding increase in the production of stock feed. At the present time between twenty-five and thirty plants are engaged in the manufacture of this material, and the annual production is over 200,000 tons.

In practice the refuse peel, pulp and seeds from the canning and concentrating plants is ground with the addition of a small amount of lime. Part of the moisture may be removed by pressing or the material may be dried directly. In either case, the limed pulp is dried in huge rotary kilns to a moisture content of from 5 to 10 percent. These dryers may be either direct fired or steam heated.

The material so produced is an excellent carbohydrate conditioning feed for both beef and dairy cattle. In many respects it is similar to beet pulp in its nutritive properties.

CITRUS MOLASSES: The press liquor resulting from the manufacture of stock feed contains about 8% soluble solids. When this liquid is concentrated under vacuum, it yields a heavy syrup of golden or orange-brown color. The material is similar to blackstrap molasses and has received the name of citrus molasses. It is used in the manufacture of mixed stock feeds and in the production of alcohol, and is also fed directly to cattle. Current production is about 50,000 tons annually.

CITRUS PEEL OIL: Orange, grapefruit, tangerine and lime peel oils are highly prized for their flavoring qualities. As their names imply, they are recovered from the outer peel of the respective fruits.

The peel is first finely ground and the resulting mass is firmly pressed. The oil is then separated from the ensuing liquid by means of a super-centrifuge. In recent years over a quarter of a million pounds of these oils have been produced annually.

ALCOHOL: Ethyl alcohol may be produced from waste citrus juices. At the present writing, one plant is engaged in the commercial production of this commodity.

WINES: Table wines of good quality can be made from citrus juices and these wines are now being manufactured commercially within the state.

MARMALADES AND JELLIES: There are numerous producers of a variety of citrus marmalades, jellies and preserves in Florida. These products have long found favor with the consuming public, and their production and use should grow.

CITRUS SEED OIL: Citrus seed oil is pressed from dried orange and grapefruit seeds. The raw oil has many uses and may also be refined to yield a superior salad oil. The press cake left from the extraction process is high in protein and should therefore prove valuable as an animal food.

For further information on by-products the reader is referred to the following bulletins of the University of Florida's Agricultural Experiment Station:

Bulletin 487, Citrus By-Products of Florida

Bulletin 469, Florida Citrus Molasses

Bulletin 452, Florida Citrus Oils

Trends in Citrus Production and the Amount Used by Processors

While citrus production in Florida has been increasing steadily during the past two decades, the percentage of the crop being processed has increased even more rapidly. In the past, more grapefruit has been processed than oranges, but in more recent years the amount or oranges used for canning purposes has also increased. This increase has been largely due to the use of oranges in the preparation of blended orange-grapefruit juice and the manufacture of orange concentrate.

Figs. 86 and 87 show the production of oranges and grapefruit in recent years and the amount of that production utilized by processors. Fig. 88 gives the percent of the grapefruit and orange crops processed.

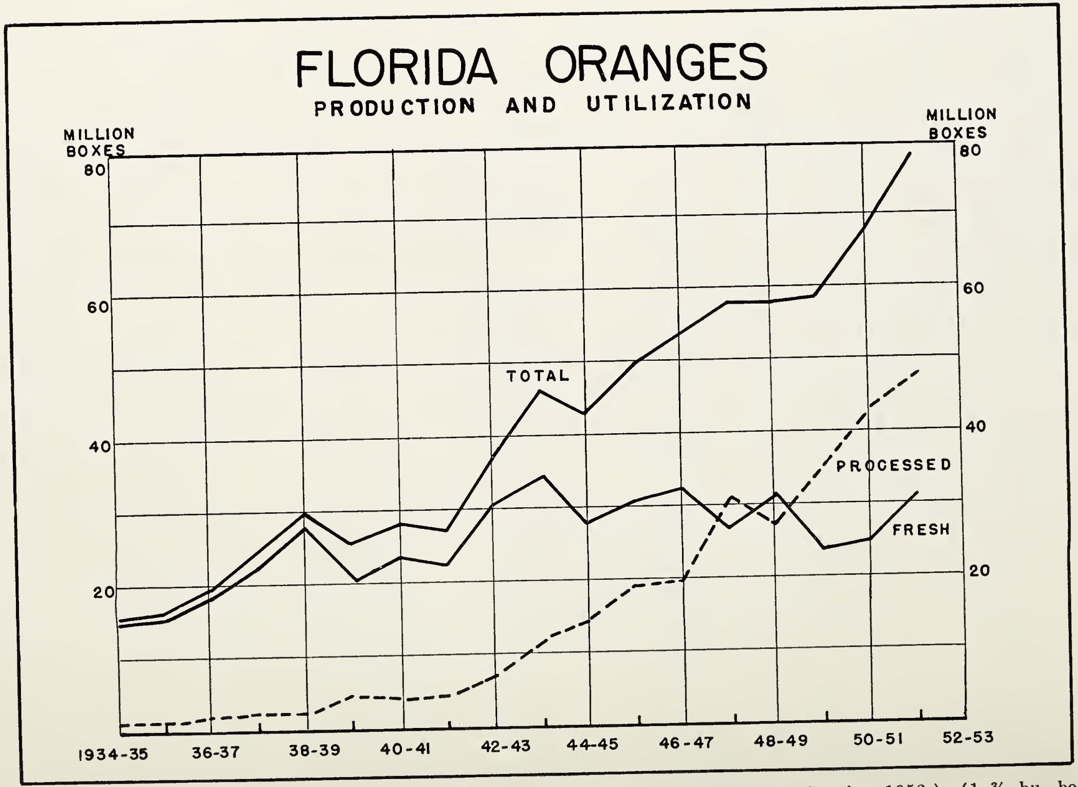

Fig. 86.—Production and utilization of Oranges. (From Fla. Crop & Livestock Reporting Service, 1952.) (1-⅗ bu. boxes)

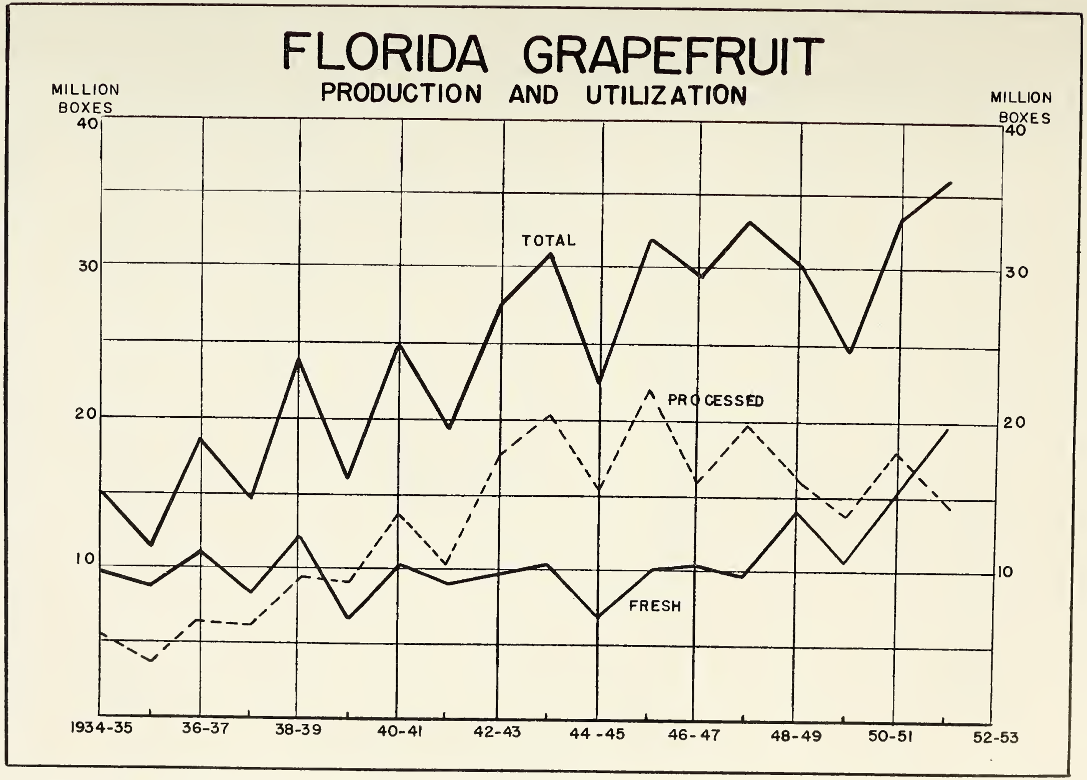

Fig. 87.—Grapefruit production and utilization. (From Fla. Crop & Livestock Reporting Service, 1952.) (1-⅗ bu. boxes)

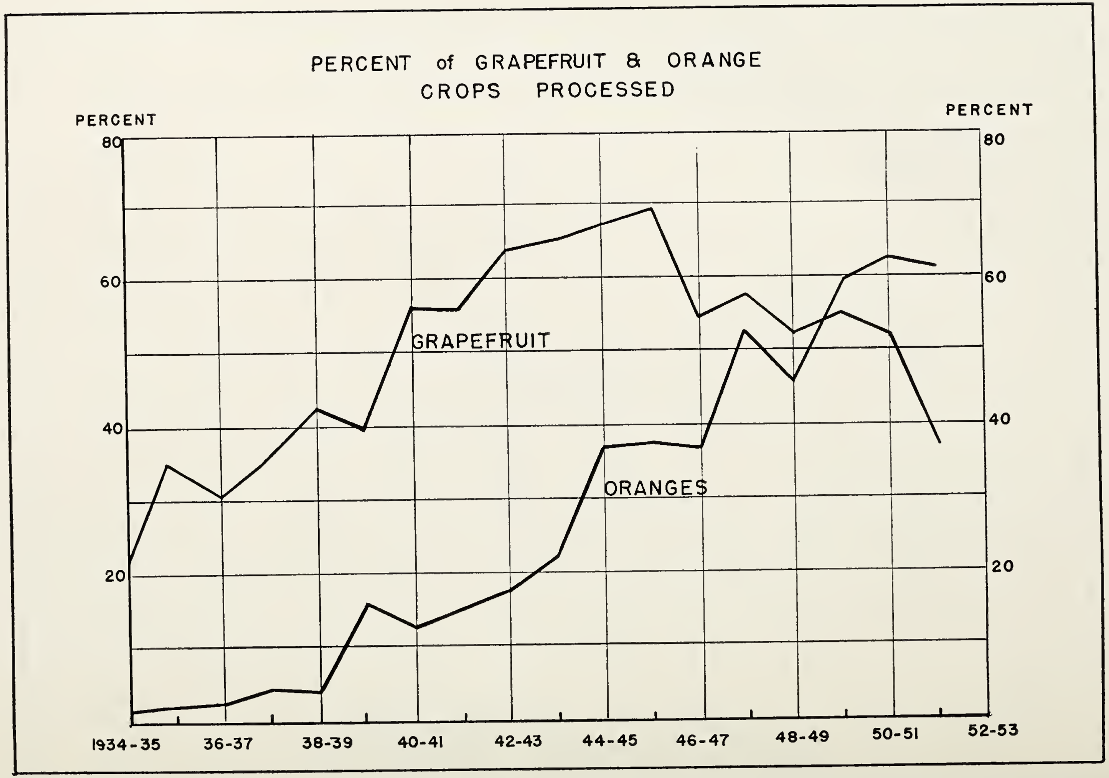

Fig. 88.—Percent of Grapefruit & Orange Crops Processed. (From Fla. Crop & Livestock Reporting Service, 1952.)

TABLE XI

PACKS OF CERTAIN FLORIDA CITRUS PRODUCTS — 1920-21 TO 1950-51

Seasons	Grapefruit Juice	Grapefruit Sections	Orange Juice	Orange Sections	Blended Juice	Tangerine Juice	Citrus Salad	Total Canned
1920-21	....	2[F]	....	......	....	....	....	2
1921-22	....	10	....	......	....	....	....	10
1922-23	....	150	....	......	....	....	....	150
1923-24	....	200	....	......	....	....	....	200
1924-25	....	350	....	......	....	....	....	350
1925-26	....	400	....	......	....	....	....	400
1926-27	....	700	....	......	....	....	....	700
1927-28	....	600	....	......	....	....	....	600
1928-29	202[F]	957	....	......	....	....	....	1,159
1929-30	174	1,317	....38[F]	......	....	....	....	1,528
1930-31	412	2,712	61	......	....	....	....	3,186
1931-32	248	907	36	......	....	....	....	1,191
1932-33	728	2,183	37	......	....	....	....	2,948
1933-34	610	2,185	58	......	....	....	....	2,852
1934-35	2,237	3,588	241	......	....	....	....	6,066
1935-36	1,758	2,252	162	......	85[F]	....	65[F]	4,323
1936-37	3,919	4,058	498	......	272	....	88	8,834
1937-38	3,370	3,419	806	33[F]	547	....	84	8,260
1938-39	5,502	4,106	926	14	699	....	131	11,378
1939-40	4,682	4,134	2,851	2	1,403	....	85	13,156
1940-41[1]	10,033	3,122	3,078	24	2,537	....	24	18,818
1941-42	6,180	4,433	3,466	1	2,304	....	1	16,386
1942-43	15,193	888	2,429	......	3,676	....	....	22,166
1943-44	16,778	942	7,075	......	6,176	....	....	30,972
1944-45	12,025	411	13,939	......	7,745	....	....	34,120
1945-46	15,089	2,407	18,421	......	12,267	....	....	48,184
1946-47	8,583	5,098	17,294	15	10,004	1,260[F]	295	42,581
1947-48	7,987	3,158	25,593	116	11,894	745	1,115	50,577
1948-49	8,843	4,238	16,757	111	10,252	1,259	987	42,447
1949-50	7,894	3,379	17,419	10	6,768	1,500	423	37,394
1950-51	12,742	4,628	20,031	35	8,797	1,158	919	48,310

[F] Means First produced.

[1] 614,193 cases packed for S.M.A. not included.

Compiled by Fla. Citrus Mutual from records of the Fla. Canners Association.

PART V

State Institutions and Agencies Serving the Citrus Industry

There are a number of organizations which carry on services devoted to the improvement and development of the citrus industry, as well as its regulation and control, all of the operations being aimed at better production and better marketing conditions. To the uninitiated there seems to be a considerable maze of official offices with their functions a little uncertain. This section is appended to this bulletin to give the grower an idea of the agencies that serve the industry and their respective functions. The following main agencies are involved:

1. The State Department of Agriculture, which carries on maturity and grade inspection, fertilizer and insecticide inspection and the enforcement of numerous regulations having to do with the packing of citrus fruit, as well as marketing work. The head of the State Department of Agriculture is the Commissioner of Agriculture, whose office is in Tallahassee, and the fertilizer and insecticide control is carried on at the laboratory of the State Department of Agriculture by the State Chemist, who is also located at Tallahassee. Enforcement of maturity laws, packing regulations, etc., is handled mostly through the office at Winter Haven. The State Marketing Bureau, which, in cooperation with the Inspection Bureau and the Federal Government, puts out a daily market report during the shipping season, is also a part of the State Department of Agriculture, but the market news bulletin is issued from Lakeland in cooperation with agencies of the Federal Government.

2. The Citrus Commission, which is a commission of 12 members appointed by the Governor to represent both growers and shippers in various geographical districts in the citrus belt, collects the advertising fees on fruit, and administers the advertising fund. It also finances a certain amount of research at various institutions, and makes regulations specified by law for the packing of citrus fruit,

which regulations are enforced by the inspectors of the Commissioner of Agriculture. It has its offices at Lakeland, Florida.

3. The University of Florida is administered by the Board of Control, members of which are appointed by the Governor for specified terms. The University, through its College of Agriculture, furnishes resident instruction in agriculture at the University at Gainesville; instruction in the various counties through the county agents; and research work on production and handling of citrus fruit through the Agricultural Experiment Stations, the major part of this citrus work being carried on at the Citrus Experiment Station at Lake Alfred, Florida.

4. The Florida State Plant Board, administrative membership of which is appointed by the Governor, and is the same membership as the Board of Control, inspects nurseries to see that nursery stock is clean and free from harmful pests when shipped; maintains a quarantine force at the borders to prevent the importation of foreign pests; and a grove inspection force to inspect groves in the state about once every two years for citrus canker and other dangerous foreign pests which might infest the groves in Florida.

The field of work of some of the above agencies does not touch the grower so directly; that is to say, maturity inspection is carried on at the packing house rather than in the grove and the whole machinery of maturity and grade inspection is primarily a packinghouse operation rather than a grove operation. The work of the State Plant Board is also routine work rather than a direct service work and is carried out on a regular schedule and inspectors are not available to make routine inspection of groves at the growers' demand. On production problems growers may obtain direct help through the County Agent in each county, and in cases where he is not informed on the problem in hand, he in turn may obtain help from the Agricultural Experiment Station.

A brief writeup on each of these organizations follows: In addition to those state organizations, the United States Department of Agriculture maintains a laboratory for research on by-products at Winter Haven, Florida; a laboratory devoted to research on production and fruit handling at Orlando; and a laboratory for entomology at St. Lucie, Florida. It also maintains a Grade Inspection Service which works in cooperation with the State Department of Agriculture and is jointly interested in the Growers' Administrative Committee, which handles the prorate problems and regulations.

The following section includes discussions of the functions of the various state agencies prepared by the respective offices.

How the Department of Agriculture Serves the Citrus Industry

In addition to the services rendered to the citrus industry by the Citrus Inspection Bureau of the Department of Agriculture, which was created strictly for that purpose, and which is financed by the industry itself through the payment of citrus inspection fees, the industry is the recipient of many valuable services from the Department which might be regarded as general services to agriculture, such as the inspection and analysis of fertilizers and fertilizer materials, insecticides, sprays and dusts. These services are rendered through the facilities of the Inspection Bureau and the Chemical Division.

Fertilizer and Fertilizer Materials Inspection

One of the principal activities of the Department is the analysis of fertilizer and fertilizer materials. Samples are drawn, by duly appointed inspectors, from fertilizer plants, warehouses, dealers, and from growers on the farm and grove. The State Chemist is charged with analyzing and reporting to the Commissioner of Agriculture all official samples drawn by inspectors of the Inspection Bureau. This analysis involves the determination of both primary and secondary plant foods. In the analysis for the primary plant foods, nitrogen, phosphoric acid and potash are determined. These elements are further broken down to show the following: nitrogen—total nitrogen, nitrate nitrogen, ammoniacal nitrogen, water soluble organic nitrogen, water insoluble nitrogen; phosphoric acid to show available phosphoric acid and insoluble phosphoric acid; and water soluble potash.

Fertilizer mixtures containing secondary plant food elements usually contain from one to as many as five secondary elements in the same mixture. Most common among the secondary plant foods found in Florida fertilizer mixtures are calcium, magnesium, manganese, copper, zinc, iron and boron. The secondary plant food mixtures are analyzed to show the oxide of the element such as magnesium oxide, copper oxide, etc.

Below is a table showing the number of fertilizer samples analyzed for the past ten years with the percentage of deficiencies, also the number containing secondary plant food elements. It is interesting to note that in 1936, the first year we tested for secondary elements, there was only a little over 12 percent of the regular mixtures containing them, but there has been a steady increase in the number containing secondary elements since that time until in 1943, nearly 50 percent of the regular mixtures contained secondary plant food elements.

FERTILIZER SAMPLES REPORTED FROM LABORATORY OF STATE CHEMIST, 1934 TO 1943, SHOWING TOTAL NUMBER OF SAMPLES AND THOSE CONTAINING SECONDARY PLANT FOODS

Year	Total No. Samples	Percent of Deficiencies	No. of Secondaries	Percent With Secondaries
1934	2113	5.2	None	------
1935	2266	5.1	None	------
1936	2213	9.8	275	12.4
1937	2511	9.4	363	14.5
1938	2719	7.4	453	16.6
1939	2518	8.6	552	21.9
1940	2864	9.0	805	27.7
1941	3627	8.4	1127	31.0
1942	3682	11.4	1511	41.0
1943	3282	13.7	1570	47.8

Insecticides and Fungicides Inspection

In 1937 the Florida Agriculture Insecticide Law was passed and the Department of Agriculture was charged with its enforcement. This law is intended to protect growers by requiring adequate and truthful labeling on all agricultural insecticides or fungicides sold in the state. All active ingredients must be shown on the label and guaranteed as to the amount contained therein. The amount of inert ingredients must also be shown.

About 750 brands of agricultural insecticides and fungicides are registered with the Department each year. It is the duty of the inspectors to draw samples for analysis as directed, and to carefully scrutinize all labels to see that they give the information required by law. Violations in this respect are growing less each year.

The Chemical Division has analyzed about three thousand samples since the passage of the Act. Approximately 12 percent of this number were found deficient or misbranded.

The enforcement of this law follows the same pattern as the fertilizer law, viz., the samples are drawn by inspectors of the Inspection Bureau and sent to the State Chemist for analysis. They are analyzed and reported to the Commissioner of Agriculture in the same manner as fertilizers. A certificate of analysis by the State Chemist on any official sample of fertilizer or fertilizer material, insecticide or fungicide, when properly endorsed is prima-facie evidence in any court of competent jurisdiction where samples are found deficient.

Citrus and Vegetable Inspection Division

The Citrus and Vegetable Inspection Division of the Florida Department of Agriculture with headquarters in Winter Haven, Florida, is the division through which the Department serves the citrus industry in a measure of protection to the industry and the consuming public.

Florida's Commissioner of Agriculture is charged with the enforcement of the Citrus Fruit Laws and the Regulations of the Florida Citrus Commission. The work of the Bureau deals chiefly with the application and enforcement of the following laws: Bond and License, Citrus Maturity, Color-Added, Frozen Fruit, Arsenical Spray, Processing Materials, Fruit for Canning, and the Grade Standardization under the Citrus Commission Law.

The Bond and License Law requires that every citrus fruit dealer obtain a license from the Department upon approval of their application by the Florida Citrus Commission, and post a bond in the proper amount with the Department before the license is granted. This Act guarantees the producer the price he is promised for his fruit and tends to eliminate the irresponsible operator. It is around this Act that the Bureau is able to enforce compliance with the several other Citrus Laws.

The Maturity, Standardization and Color-Added Acts deal chiefly with the inspection and certification of the quality of the fruit, both internal and external. Inspection of the fruit and certification of same is made only at registered processing plants, packing houses and canning plants within the state, while it is being prepared for fresh fruit shipments or for processing. It is required that each lot of fruit meet the requirements of state maturity laws and the grade standards adopted by the Florida Citrus Commission. All fruits processed for canning must be sound and mature. An inspector is maintained at each packing house and canning plant within the state during its entire operation, the larger houses requiring the services of two or three men.

The State Certificates cover grade, maturity and color-added requirements, regulations and other necessary information for tabulation at the Winter Haven office. The certificates are issued in quadruplicate copies. The fourth copy is retained by the inspector, the third copy delivered to the shipper, the second copy is required filed with the transportation company upon acceptance of shipment, and it is this copy which bears the proper denomination of cancelled revenue stamps in payment of inspection fees and advertising assessments. The first or original copy of the certificate is sent to the Winter Haven office accompanied by the complete shipper's manifest, where both the certificate and manifest are audited by the statistical department of the Bureau. Weekly tabulations of shipments by grade and size are furnished the Growers' Administrative Committee for their use in administering the Marketing Agreement.

The field service of the Bureau operates through fifteen districts throughout the citrus belt, each of which is headed by a supervisor under whom each inspector works directly in carrying out the various duties he is assigned to perform. It is through the District Supervisors that the Bureau maintains its direct contact with the field force, and each shipper or processing operator. The field force of inspectors varies in direct ratio to the tonnage moving, numbering from 225 at the peak of the season to less than 25 during the summer.

The total operating costs of the Bureau and service are paid by the citrus industry through inspection fees set forth in the various laws, according to the services rendered in the inspection of fresh fruits or fruit for processing.

The Department of Agriculture maintains chemical laboratories at Bureau headquarters in Winter Haven, where processing materials such as color-add dyes, waxes, oils, soaps, etc., used in processing citrus fruits are analyzed and authorization for use granted after it has been proven that they contain no foreign materials which may damage the fruit when used. The regular work in enforcement of the law prohibiting the use of arsenical sprays is handled through these laboratories. Additional work has been done in the laboratories for the past three seasons consisting of a project assigned to us by the Florida Citrus Commission's research department on internal qualities of citrus fruits.

At the Bureau's headquarters in Winter Haven there is a tabulation of wires received from each of the several districts giving a daily citrus shipping report. This report is released to the press at 10:00 a.m. each day and may be obtained by any operator by wire or telephone upon request. It covers the previous day's operation in total volume of shipments, fruit packed, unprocessed, and the estimated pickings, by kinds of fruit.

The Department operates eight Road Guard Stations at strategic points on the highways leading out of Florida, throughout the shipping season, in order that all truck shipments of citrus fruits be intercepted for clearance papers. Truck passing reports are submitted to the Citrus Inspection Bureau's headquarters in Winter Haven daily, and copies are sent to the Federal-State Market News Service, Lakeland, Florida, for use in listing interstate destinations.

The work of the Citrus Inspection Bureau may be best summed up as a service to the citrus growers of the state which protects the industry on two vital points: (1) It requires all citrus fruit dealers to be bonded and licensed and to meet their commitments. (2) It makes certain that the fruit does not leave the state or is processed within the state unless and until it meets all requirements under the Citrus Laws and the Florida Citrus Commission regulations.

State Marketing Bureau

The State Marketing Bureau furnishes federal-state inspection for car lot shipments. The grade and condition of shipments as certified by inspectors are used in court in case of dispute between shippers and consignees, or buyers or transportation companies as to grade and condition at point of shipment.

The State Marketing Commissioner also furnishes citrus market news to the public, to the daily press and by radio.

Grade and Size Marketing Agreement

Interstate shipments of Florida oranges, grapefruit and tangerines are controlled by a Federal Marketing Agreement and Order. Administering the Agreement and Order are two committees, the Shippers Advisory Committee and the Growers Administrative Committee, the members of which are selected by the Secretary of Agriculture from nominations made by the industry.

Guided by market conditions, the Secretary of Agriculture, upon recommendation of the committee, restricts interstate shipments to the most desirable grades and sizes. The Agreement and Order have been in operation since February 22, 1939.

Florida Citrus Commission

The Florida Citrus Commission consists of twelve representative growers and shippers of citrus fruits. Its members are appointed by the Governor and serve at no salary.

Some of the duties of the Citrus Commission have been outlined in the chapter on Marketing. Its other duties follow:

1. ADVERTISING. Under state laws assessments of three, four, four and five cents, respectively, are collected on each box of oranges, grapefruit, seedless limes and

tangerines shipped in fresh form or processed, (the excise tax on Temple oranges shipped in fresh form is five cents per box). These funds, which aggregate approximately $3,700,000 annually, are used largely for the advertising and publicizing of Florida citrus fruits, both fresh and canned; and for sales service work in consumer markets through all of the recognized channels of distribution.

2. Research. To establish and conduct a Research Department, with primary functions of determining new uses for citrus fruits, development of new and improved products, and by-products, improved methods and means of distribution and handling of fruit and products, and development of facts concerning the health-giving qualities of citrus. Five percent of total advertising tax revenues may be used for this purpose.

3. Transportation. To investigate transportation rates, regulations or practices which affect the Florida citrus industry. Three percent of total advertising revenues may be used for this purpose.

University of Florida, College of Agriculture

The College of Agriculture, one of the seven colleges comprising the University of Florida, consists of three separate but closely integrated divisions—resident instruction, the agricultural extension service and the agricultural experiment stations.

In the division of resident instruction the major function is the academic training of students in agricultural subjects. The curricula offered, all leading to the bachelor's degree, comprehensively cover the many and varied phases of agricultural knowledge and permit wide specialization fitting the need and desire of the student.

The Agricultural Extension Service with its corps of county and home demonstration agents carries new knowledge directly to farms and farm homes and demonstrates the benefits accruing from improved practices. The county agent's programs cover farm crops, livestock, horticulture and marketing, and those of the home demonstration agents include gardening, poultry, sewing, canning, preserving, home improvement and home marketing. One of the outstanding projects is the 4-H Club work with both boys and girls.

The Agricultural Experiment Station is the research division of the college and is charged with the responsibility of discovering solutions to the complex and constantly arising problems of Florida's diverse agriculture. It is the state's only agricultural research institution and its major activities are in agronomy, agricultural economics, animal husbandry and veterinary medicine, soils, entomology, horticulture, plant pathology and home economics. Since its establishment the Station has been an unbiased agency in the development and dissemination of new and authentic information. Conducting researches and experiments for the improvement of the state's agriculture, it has neglected no phase of farming activity. An appraisal of the results attained shows them to have been productive of numerous widely varied practices, methods and materials now in everyday use and established as essential in the production programs of the several agricultural fields. To meet the definite and pressing need for specialized research on specific crops and problems of the different areas, five branch stations and seven field laboratories have been established. These stations and laboratories, staffed by scientists with specialized training in their respective lines of research, and their scope of activities are as follows:

CITRUS STATION, Lake Alfred. All phases of citrus production and utilization.

NORTH FLORIDA STATION, Quincy. Tobacco, livestock and general farm crops of the northern Florida area. Headquarters for the three mobile agricultural research units.

EVERGLADES STATION, Belle Glade. General agriculture of the mucklands of the Everglades.

SUB-TROPICAL STATION, Homestead. Sub-tropical fruits and winter vegetable production.

RANGE CATTLE STATION, Ona. Range cattle production and pasture improvement.

Watermelon Laboratory, Leesburg. Culture, disease and insects of watermelons, grapes and Sea Island cotton.

Strawberry Laboratory, Plant City. Culture and disease of strawberries.

Potato Laboratory, Hastings. Culture and disease of potatoes and vegetables.

Pecan Laboratory, Monticello. Pecan insects.

Vegetable Crops Laboratory, Bradenton. Culture, diseases and insects of vegetables and gladioli.

Celery Laboratory, Sanford. Culture, disease and insects of celery and other vegetables.

Frost Forecasting Laboratory, Lakeland. Cooperative with U. S. Weather Bureau. Frost forecasting covering all of the peninsula during the winter months.

Growers may obtain results of this research work through bulletins and press bulletins published by the Experiment Station, through articles in agricultural magazines and by contact with the research workers themselves.

State Plant Board

The State Plant Board is charged with the responsibility of protecting Florida's agricultural and horticultural interests from the introduction, establishment and dissemination of dangerous plant pests and the control or eradication of such major pests as may gain entrance, when such procedure is deemed necessary or practical.

Source of authority under which the Plant Board operates is the Florida Plant Act of 1927, which replaced the Plant Act of 1915. The legislature, reluctant to increase the number of boards of commission existing at the time the Plant Act was passed, directed that the State Plant Board be composed of the same individuals who compose the Board of Control, in charge of the institutions of higher learning. This arrangement tends to economy of administration and provides a close and mutually advantageous relation between the regulatory force and the research and educational organizations. Board members are appointed by the Governor, and serve for four years without compensation.

The extent to which protective measures are used by the several states depends upon the relative value of the agricultural interests. States whose interests are primarily of a manufacturing or mining character do not take as intense interest in protecting agriculture as do those where the production of fruits and winter vegetables is paramount. Florida is an agricultural state. Its geographical location is such that it is more exposed than any other state to invasion by plant pests, especially from foreign countries. Transportation facilities from these alien lands are so highly developed as to magnify greatly the possibilities of introduction of serious plant pests. In Florida the same favorable conditions which contribute to bountiful yields likewise make possible the rapid development of plant pests. Only by maintaining well organized nursery, grove, and quarantine inspection forces can the state's plant life be protected against attacks by plant pests.

The Plant Commissioner is the chief executive officer of the State Plant Board, and has general direction of field activities. The major departmental activities are:

Nursery Inspection, Grove Inspection, Quarantine Inspection, Apiary Inspection and Entomology.

NURSERY INSPECTION: Regular and frequent inspections of nurseries are essential for the well-being of the state's horticultural interests. If a major plant pest becomes established in a nursery and there are no restrictions on the movement of nursery stock therefrom, the pest will be promptly disseminated from one end of state to another. It is a matter of record that the first inspection of "exposed" nursery stock shipped from citrus canker infected nurseries before the creation of the Plant Board brought to light 62 centers of infections scattered through 21 counties. Fifty-six, or 90 percent, of these infections were found on shipments made from one infected nursery.

For inspectional purposes the state is divided into eight districts, with an assistant nursery inspector in charge of each. The chief nursery inspector has headquarters in Gainesville. District headquarters are located at Miami, West Palm Beach, Orlando, Winter Haven, Eustis, Tampa, Bradenton, and Gainesville. Nurserymen frequently seek advice of and information from the nursery inspectors as to the control of insects and diseases, as well as cultural practices. Inspection and certification are necessary in order to make shipments to points outside the state. Some 4,500 acres of land are devoted to growing nursery stock, on which are located some 46,000,000 plants, approximately 7,500,000 of which are citrus.

Grove Inspection: The Board's budget provides for the employment of one chief and twenty-eight assistants—a number sufficient to make one complete coverage of the state's 26,000,000 citrus trees about once every two years. However, these employees are at times called upon to make inspections of Irish potato plantings, special surveys of fields and groves following reports of the presence of some new pest, and similar activities. These interruptions, coupled with the fact that under war-time conditions it has not been possible to find sufficient qualified men to serve as grove inspectors, have seriously interfered with the inspection schedule. One full coverage every three years is the best that can be done under present conditions.

Quarantine Inspection: Risk of entry of foreign plant pests has greatly increased under war-time conditions. Florida is the site of numerous commercial and service airfields, at which planes land from almost every country in the world outside German-controlled Europe. Air—and watercraft arriving at the principal ports of entry—Pensacola, Jacksonville, West Palm Beach, Fort Lauderdale, Miami, Homestead, Key West, and Tampa—are boarded by Plant Board inspectors, who hold appointments as collaborators of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, and as such have authority to enforce federal plant quarantines. Approximately 1,000 planes a month are boarded. All baggage carried by crews and passengers, ships' stores, and cargo are checked for the presence of contraband plant material. Plants or plant products affected with insects or diseases are frequently confiscated. Many destructive plant pests, including the Mediterranean fruit fly and the Morelos orange maggot, have been intercepted.

The inspectors also enforce domestic plant quarantines, and plants and plant products arriving by mail, freight or express pass under their scrutiny.

The tremendous expansion of air traffic will continue after the war, and the risk of entry of alien insects and diseases will be magnified many times. Plants and plant products from Africa, Europe, Asia, and South America will be transported by air. As such movement will consume only a few days, the material will arrive in the United States in good condition. Such plant pests as may be present will also arrive in good condition, ready, if opportunity presents itself, to start an infestation in this country. Large Army and Navy airfields located in the interior of the state will, in all probability, be designated as disembarkation points for returning civilian and military personnel, and the resources of the State Plant Board will be strained to the limit to provide adequate foreign plant quarantine enforcement.

APIARY INSPECTION: Beekeeping is an important cog in the machinery of war. Army and Navy officials have requested a considerable increase in the production of beeswax, which is used for coating all projectiles from a rifle bullet to a 16-inch shell, as well as waterproofing coils and wires in aircraft, tanks, and trucks. There is a great demand for honey as a substitute for sugar, particularly on the part of the baking industry. The yield of some essential crops would be too low to pay for costs of production were it not for the cross-pollination of blossoms by bees in their search for nectar and pollen. Thus the need for protecting this industry from losses resulting from attacks by disease, American foulbrood in particular, is a considerable one. This is the task of the Apiary Inspection Department, which derives its authority from the Florida Bee Disease Law of 1927.

ENTOMOLOGICAL DEPARTMENT: The imposition of a quarantine on a nursery or grove, or the refusal of entry of nursery stock or other plant material, is a serious matter, one that should not be left to the judgment of the field inspectors. In order that there may be no unfairness to the interests involved and the administering officers may act intelligently, examination of suspicious material by trained specialists is necessary. The Plant Board employs one entomologist and utilizes the services of the pathologists of the Agricultural Experiment Station in making examinations of infested and infected plants and plant products collected by the Board's inspectors.

During the nine-year period, 1935-'43, the average annual cash income from the sale of Florida's farm products (excluding government payments) was $151,642,000. Of this total 36.9 percent or $56,016,000 was received from the sale of citrus; 31.9 percent from truck crops; and 31.2 percent or $47,228,000 from all other products. Surely this is an investment well worth protecting.

TABLE XII—AUCTION SALES IN TEN TERMINAL MARKETS
STANDARD BOXES

		Oranges	*Grapefruit*	*Tangerines*
1932-33	New York	$2.43	$2.05	$2.56
	All Auctions	2.44	2.06	2.48
1933-34	New York	2.75	2.41	2.42
	All Auctions	2.70	2.39	2.40
1934-35	New York	2.61	2.04	2.36
	All Auctions	2.56	2.00	2.36
1935-36	New York	3.02	2.67	2.70
	All Auctions	3.00	2.57	2.70
1936-37	New York	3.23	2.24	2.24
	All Auctions	3.21	2.23	2.20
1937-38	New York	2.26	2.20	2.52
	All Auctions	2.24	2.16	2.48
1938-39	New York	2.10	1.75	2.14
	All Auctions	2.09	1.72	2.00
1939-40	New York	2.43	2.21	2.74
	All Auctions	2.35	2.13	2.74
1940-41	New York	2.37	1.96	2.46
	All Auctions	2.35	1.91	2.38
1941-42	New York	2.86	2.55	3.72
	All Auctions	2.83	2.52	3.58
1942-43	New York	3.85	3.18	3.64
	All Auctions	3.79	3.10	3.60
1943-44	New York	3.98	3.63	4.32
	All Auctions	3.90	3.56	4.46
1944-45	New York	4.62	4.35	4.84
	All Auctions	4.48	4.24	4.82
1945-46	New York	4.72	3.88	5.34
	All Auctions	4.58	3.82	5.22
1946-47	New York	3.60	3.39	4.56
	All Auctions	3.50	3.29	4.34
1947-48	New York	3.40	3.22	4.18
	All Auctions	3.27	3.07	3.96
1948-49	New York	4.35	3.87	5.50
	All Auctions	4.23	3.77	5.10
1949-50	New York	5.10	5.38	5.48
	All Auctions	4.95	5.10	5.26
1950-51	New York	4.49	4.33	5.32
	All Auctions	4.39	4.05	5.12
1951-52*	New York	3.89	4.03	5.68
	All Auctions	3.75	3.88	5.26

*Temple Oranges Included.

TABLE XIII—ESTIMATED AVERAGE RETURNS STANDARD BOX

1931-32 TO 1951-52 SEASONS

	F. O. B. RAIL & BOAT SHIPMENTS ONLY			ON TREE—ALL PRODUCTION STANDARD BOX		
	Oranges	*Grapefruit*	*Tangerines*	*Oranges*	*Grapefruit*	*Tangerines*
1931-32	$2.30	$1.50	$2.05	$1.31	$0.62	$0.80
1932-33	1.48	1.16	1.42	.62	.27	.38
1933-34	1.71	1.51	1.80	.88	.62	.85
1934-35	1.85	1.29	1.66	.98	.38	.76
1935-36	2.30	1.87	2.00	1.33	.85	.97
1936-37	2.50	1.48	1.45	1.48	.55	.32
1937-38	1.56	1.53	1.86	.63	.54	.66
1938-39	1.43	1.04	1.34	.54	.21	.38
1939-40	1.62	1.42	2.00	.59	.39	.92
1940-41	1.63	1.21	1.68	.72	.33	.58
1941-42	2.10	1.80	2.85	1.13	.74	1.67
1942-43	2.97	2.33	2.78	1.85	1.02	1.38
1943-44	3.10	2.47	3.70	1.81	1.32	2.01
1944-45	3.50	3.00	4.25	2.23	1.76	2.56
1945-46	3.55	2.65	4.80	2.32	1.12	2.74
1946-47	2.62	2.18	3.75	1.03	.63	1.58
1947-48	2.10	1.80	2.90	.65	.34	.88
1948-49	2.80	2.35	3.70	1.29	.68	1.42
1949-50	3.55	3.41	3.85	2.03	1.89	1.50
1950-51	3.12	2.73	4.35	1.39	.99	1.73
1951-52	2.46	2.36	4.30	.84	.68	1.79

Compiled by Frank S. Scruggs, Market News Specialist, Florida State Marketing Bureau, November 1, 1952.

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